BULLETIN

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DENISON UNIVERSITY

C. L. HERRICK, EDITOR.

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[Material from the Scientific Laboratories.]

GRANVILLE, OHIO, DECEMBER, 1888.

ERRATA.

Page 12. For LINGULA WAERLYENSIS, read L. WAVERLIENSIS.

Page 14. For CHONETES TUMIDUS, read C. TUMIDA.

Page 18. For L. WAVELYENSIS, read L. WAVERLIENSIS.

Page 24. The figure referred to as Fig. 12, of Plate III, has been omitted from the plates.

Page 29. For ALLORISMA CONSAGUINATUS, read A. CONSANGUINATA.

Page 37. Under bibliography, for MACORDON, read MACRODON.

Page 38. Under C. ovata, for PLATE IV. FIG. 6, read FIG. 5.

Page 43. et seq. The proper orthography is probably PALÆANEILO.

Page 44. For NUCULA HOUGHTONI, STEV., read N HOUGHTONI, WIN.

Page 45. For FLEMINGIA STULTUS, read F. STULTA.

Page 54. For PHILLIPSIA (PROETUS) AURICULATUS, read PROETUS (PHLLIPSIA?) AURICULATUS, and make the same change in case of P. praecursor.

Page 54. For PHILLIPSIA MERAMACENSIS, read P. MERAMECENSIS.

Page 78. For PLATE IV, read PLATE XIV

Page 99. Correct the numbering of the paragraphs.

Page 100. For SHUZODUS, read SCHIZODUS.

Page 101, (16). Add, at end, 100 FEET.

Page 107. Six lines from bottom, for ELIKE, read LIKE.

Page 118. Under Plate III. instead of LEIORHYNCNUS, read LEIORHYNCHUS.

We embrace this opportunity to extend public thanks to those who have aided in the work here represented. To Prof. L. E. Hicks for a valuable collection of New England plants collected by A. R. Crandall. To Prof. W. H. Johnson for a fine suite of fresh-water vertebrates, mostly fishes, from the Ohio river. To Mr. Geo. W. Spellman for a collection of Trenton fossils from Southern Wisconsin. To Mr. J. A. Smith for a collection of about fifty plants from Mercer's Bottom, West Virginia. To numerous scientific societies and individuals who have added to our library. To all who, by word of cheer or pecuniary aid, have encouraged the project of enlarging the scope and increasing the efficiency of the scientific departments.

We present herewith an elevation and diagrams of a building intended to accommodate the scientific departments of one of the smaller colleges. The plan was suggested by the departments and has been elaborated by the Messrs. Richards, architects, of Newark, O. The design was to comfortably house and provide for such an outfit as would best subserve the requirements of a modern college with less than five hundred students. At the same time, the building is so arranged that, by the removal of a few slight partitions, it is easily adapted to the sole use of the departments of Geology and Biology, and the necessary museums and laboratories. The following advantages incident to this plan should be noted. The space is rigorously economized. The museum is essentially distinct from the laboratories and class-rooms, yet is closely united to both, as well as convenient to the entrance. In this way the museum may be rendered fireproof without fire-proofing the entire building. The class-room of geology is so arranged that, by removing iron shutters which move on weights the gallery of the museum is instantly brought within the view of the entire room, thus enabling the instructor to point out the various geological periods as illustrated by the charts and cabinets without disturbing the recitation. A door leads from the geological class-room to the gallery and from the preparator's room to the first floor of the museum. The single large lecture room is equally eligible to both departments and is of the amphitheater style so much in vogue abroad. There are approaches from without, as well as from the hall, so that

classes may leave the building without disturbing others engaged in laboratory practice. The first, or basement floor, is devoted to a light and convenient work-shop. The shaft running the iron and wood-working machinery is continued into the lathe room of the lithological laboratory. The laboratories for physics are supplied with firm piers for delicate instruments, while microscope tables in the biological rooms may be so bracketed to the walls as to be quite independent of possible floor vibrations. A large and well-lighted room in the attic may be used in any way desired. The following added particulars are furnished by the architects:

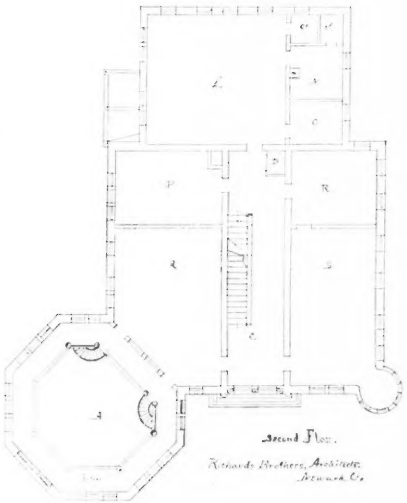
The building will cover a space 56 ft. 8 in., by 79 ft., exclusive of entrance porches or tower projections. The octagonal museum room has a projection of 22 ft. 6 in. The materials used in construction will be native freestone and pressed brick, trimed with Kilbuck brown sandstone, and, for the roof, slate and iron. The interior should be furnished in cherry, oak and ash. The building will be heated by steam, lighted by electricity from dynamos in the basement, and ventilated by the latest improved methods. Water plumbing throughout, with toilet rooms and the L. B. Robb patent crematory closet system complete the appointments of the building proper. The estimated cost falls between $25,000 and $35,000, depending upon the detaiis of construction.

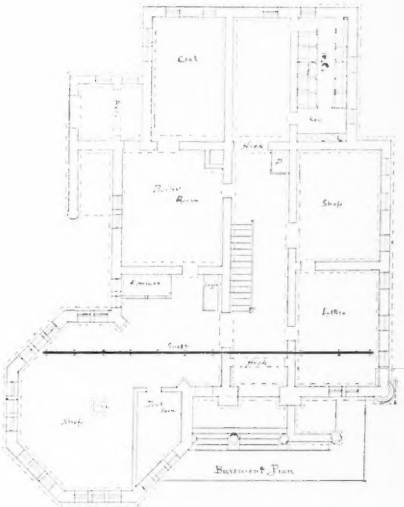
EXPLANATION OF DIAGRAMS.

A. Museum.
B. Biological preparation room with dark-room and closet.
C. Halls.
D. Elevator shaft.
E. General physical laboratory.
G. Delicate instruments.
H. Lecture room, with raised amphitheater seating.
I. Chemical preparation room.
K. Physical preparation room.
L. Chemical laboratory.
M. Lift.
N. Stock room and dark room.
O. Balance room. Spectroscope room adjoining dark room.
P. Mineralogical laboratory.
Q. Class-room of mineralogy and geology, separated from gallery of museum by glass sash and a steel shutters.
R. Chemical laboratory study. Organic and gas analysis.
S. Biological laboratory.


First Floor


Richards Brothers Archts
Front Elevation


Second Floor.
Richards Brothers, Architects.
Newark O.


Basement Plan

ite is also present in abundance in short, irregular crystals, some of which is uralitic, showing alteration to hornblende, and contains inclusions of magnetite grains. Some of the augite grains are polysomatic. Olivine is also scattered through the section showing brownish alteration along margin and cleavage lines. Magnetite and apatite are also present together with a few grains or scales of hematite. No garnets were found in this section. Dialage is doubtfuly determined. The rock is a typical Olivine Diabase.

The next sample studied was obtained near this trap and is of a coarser granular structure and lighter colored. Large crystals of quartz and plagioclase are scattered through it. In section the same displays a field, the greater portion of which is hornblende in short irregular crystals, forming the main mass of the rock. Through this are scattered crystals of orthorhombic augite, enstatite, apparently an alteration product of the hornblende. The plagioclase is in small lath-shaped crystals of labradorite and together with quartz, forms a small portion of base. A few crystals of magnetite and apatite are present with a few scales of hematite as an alteration product of magnetite. Another rock sample taken from near the contact line, is of a finer crystalline structure having cooled more rapidly from a state of fluidity. It is dark gray in color with reddish brown spots containing garnets scattered throughout; one exposed edge giving indications of weathering. In section we find hornblende in short irregular crystals forming nearly one-half the mass with labradorite feldspar in abundance, and interpenetration quite noticable as indicating secondary origin. They also contain cavities of air or glass. Garnets in some cases occupy a great part of the field; they are of a salmon red color and contain inclusions of magnetite dust and fluidal cavitites. Near these is found quartz and feldspar and a little magnetite in regular sections. These two last rocks mentioned are Diorites and are thought from the position and structure to be products of the action of the diabases upon the metamorphic rock through which the diabase has forced its way to the surface. The gneisses and schists, according to the geological map of that state, lie unconformably upon the underlying rock and have probably a sedimentary origin. The diorites seem not to be simply diabase altered to diorite, as maintained by Mr. Wadsworth, but are perfectly fresh and it rather seems that these rocks are paragenetic and the formation of diorite is accounted for by contact with the diabase, which by means of its heat fused the surrounding

local rock to a plastic mass, which upon recrystallization assumed the distinctive characteristics noted above.

The next rock studied from this neighborhood is a piece of fine-grained gneiss, of dark geenish gray color almost schistose structure and is from the rock surrounding the trap. When studied microscopically, we find the greater part of it to be hornblende in short, irregular crystals, with a few large crystals of the same containing inclusions of apatite, with magnetite and calcite as product of alteration. Quartz is present with a few scales of biotite and many crystals of apatite. One thing noticeable in the rock, is the peculiarity of the form and occurrences of the calcite. In almost every case observed, it was formed either lying within or adjacent to a crystal of hornblende and always enclosing grains or skeletons of magnetite, except in two or three cases and in those cases the enclosed particles are hematite, which are undoubtedly alteration products of magnetite. The calcite has apparently assumed the form of the original magnetite crystal or the space occupied by it and the adjacent hornblende alteration product.

Fig. 1. Sec. A., is a crystal of hornblende containing calcite (c) undoubtedly an alteration product, and enclosing a crystal of magnetite; (a) is a cross section of apatite. Fig. 2, is a crystal of calcite with slightly greenish tinge, as indicating its probable origin, showing the cleavage of calcite and surrounding a grain or skeleton of magnetite. Fig. 3, is a crystal of calcite with an enclosed scale of hematite altered from magnetite. It will be noticed that the calcite grains are nearly regular in shape and apparently assume the form originally held by the magnetite. Such is the case in almost every instance. There are however, a few crystals, as in Fig. 4, where the hornblende has altered along the edges with the magnetite skeleton within, and the whole forming an irregular crystal.

Two theories are proposed in regard to this change; one is that it was brought about by the presence of carbonic acid in the interstitial water of the rock, by means of which interaction was set up between the magnetite and hornblende, substituting iron for calcium in the latter, depositing some of its calcium as calcite about the remnant of the magnetite; or it may be a pseudomorphic product of the hornblende leaving the magnetite as a residue.

Our two next studies are different phases of granite from the quarry about two miles east of the dyke. The rock is a true granite and is extensively quarried. Macroscopically they differ in general only in color. One a dark and the other a light gray, with, perhaps, slight indications of weathering on the surface of the darker rock. It

also contains small brownish crystals, that might be taken for garnets, but are simply colored augite. There also passes across this specimen a small greenish segregation vein. Microscopically, the specimen presents a field in which quartz and orthoclase are abundant, considerable biotite, epidote, some calcite, augite, hornblende, a little muscovite, oligoclase, magnetite, and a few scales of hematite. The biotite is in both long and short crystals. The epidote is in slender irregular crystals of a greenish yellow color, in some instances showing paramorphic alteration from hornblende. One peculiarity of this granite is the presence and abundance of augite in association with orthoclase, which is a rare thing; but here the numbers of augite crystals are surprising. It varies from brown to pale brown in color. The other phase of this rock, as has been said, is of a lighter shade, somewhat speckeled and of coarser crystaline structure, with some of the constituents distinguishable by the unaided eye. Microscopically, the section shows quartz and orthoclase in considerable quantity. Biotite is present, and in some cases shows pseudomorphic alteration from hornblende. Muscovite is more abundant than in the former, in irregular grains, with hornblende, calcite, and a little magnetite.

The three following rocks studied, are different phases of the schist of this region and present a very interesting problem on account of the topographical and lithological evidence they furnish of the gradual alteration from actinolite schist through the various other varieties of schist to the pure steatite or soapstone. There is a quarry of this soapstone, about two miles from the dyke, and its merchantile value gives it at once a leading place in interest.

The first rock studied is a schist taken at some distance from the soapstone. To the unaided eye it is dark green in color with fine felting of crystalline rods, and harsh gritty touch. Under the microscope it presents a field of actinolite-honblende, very beautiful either with or without the polarizer, on account of the distinct outline of the crystals, many of which have a beautiful yellowish green border. Some of the crystals of hornblende are partly altered to tremolite as in Fig. 5, Sec. B, showing the green of the hornblende (h) and white of the tremolite (t) in different parts of the same crystal; the alteration is incomplete. All stages of transition from actinolite to tremolite are observable. Others have made a further change and are taking on the fibrous structure of talc. The rock is an actinolite-schist with tremolite, a little magnetite

and yellowish isometric crystals of alteration product not yet further determined.

The second sample taken nearer to the soapstone quarries, is a fine grained crystalline rock, brownish gray color with here and there groups of garnets of a rusty appearance. Talc is perceptable to the unaided eye. Under the microscope we find the field mainly hornblende of a brownish color, all more or less altered. An unresolvable mass of "opacite" is scattered through it. Also numerous large scales of talc more abundant in this than in the former sample. Some scales of biotite, quartz, magnetite crystals, a little muscovite and a few small garnets.

The next rock is the steatite rock itself. In hand sample it presents a felting of stellate or rosette masses of crystals, of light greenish gray with brownish or orchre colored aggregates at centre of rosettes. The whole has an unctuous touch. Microscopically, it is seen to be almost wholly talc with here and there large crystals showing traces of the form of original hornblende.

Comparing our studies of these three rocks, we find the first an Actinolite schist with the hornblende almost pure and containing tremolite and a few talc crystals; and as we draw nearer to the soapstone, we find the rock to contain hornblende all more or less altered with more talc present, making it a talc schist, until we reach the pure talc rock containing but few traces of the original hornblende structure. Followed consecutively, the change would probably not be so apparent, but from these samples taken at different distances from each other the change is quite marked, and we conclude that the soapstone was formerly a gneiss or schist and that its present condition is due to the alteration of the hornblende to talc brought about by atmospheric or hypogene forces. Whether the period occupied in bringing about the transformation was of long or short duration we cannot say.

In this series of rocks we find the points of interest to be the interpenetration and the pereklite twinning of the plagioclase crystals, some of which in the first diabase studied are evidently formed under pressure; the polysomatic structure of the augite in both diabases; the absence of garnets in the diabase and their presence in the adjacent genisses, schists and diorites where ever studied, in which our experience differs from that of Mr. Lawson in his article in the April *Geologist*, where he says he finds garnets in the central portion of the dyke studied by him and none in contact rocks or schists, this leading

to the conclusion that garnets are of probable contact origin; then the peculiarity of the formation and occurence of calcite in connection with magnetite which we have never noticed before in any rock we have studied;* the association of augite and orthoclase in granite—a very rare occurence; and finally the gradual alteration of the schists to steatite or soapstone.

*See Rosenbusch, Micro-Physiographie. Vol. II, p. 247.

GEOLOGY OF LICKING COUNTY. PART IV.

By C. L. Herrick.

List of Waverly Fossils, Continued.

In this number a considerable number of additional species are described and additional information collected concerning many noticed in the last number. Especial pains has been taken to figure characteristic specimens of the new species and it is hoped that several deficiencies in the last paper are now met. The Bryozoa constitute the basis for a separate paper by Mr. Ulrich to whose generosity we are greatly indebted. It is frankly admitted that a great deal remains to be done, nevertheless this paper is based upon much larger collections of Ohio Waverly fossils than ever before accumulated and one derived from nearly all parts of the state,

If circumstances had permitted, it was intended to prepare an artificial key to genera and species of the Waverly group. This we can not at present do, for to make it of real value it should include the species of Michigan, Iowa, Tennessee and Pennsylvania. In a few cases a key has been prepared for brachiopods. The genera of Lamellibranchs can be collated by reference to Vol. V. of Palæontology of New York and the number of species here reviewed is too small to require special keys. In bringing this list to a close the leniency of students is relied upon in view of the extreme difficulty of the undertaking and the nature of the material. In the object set prominently before the mind, the reference of species to their exact horizon, we hope to have measurably succeeded.

KEY TO THE BRACHIOPODA OF THIS LIST.

A. BRACHIOPODA.

a'. Lyopomata.

Valves of the delicate shell not articulated by teeth, form sub-discoid or linguloid, texture more or less horny.

I. Fam. Discinidæ. Upper valve sub-conical or limpet-like, lower flat and perforated for the pedicel.

II. Fam. Lingulidæ. Shell oblong or oval, valves nearly equal.

I. Fam. Discinidæ.

Genus 1. Discina. Flat lower valve with a perforation on the posterior side, with an internal furrow.

Strangely enough no well-authenticated species of Discina is yet known in the Ohio Waverly. From other states the following are rather imperfectly known: *D. gallaheri*, Win. (Mich.) *D. patellaris*, Win. (Iowa), *D. safforti*, Win. (Tenn). D. capax is thought a synonym of O. newberryi, and a specimen from Granville has been identified by Prof. Winchell with D. gallaheri perhaps on insufficient grounds.

Genus 2. Orbiculoidea. Furrow impressed from the outside instead of the inside the lower valve, opening at its posterior end.

Sp 1. Orbiculoidea newberryi. H.

Nearly circular, apex of ventral valve one fourth diameter from the margin, indistinct radiating markings. Less than half an inch in diameter. Div. I, and especially just above Berea grit.

Sp. 2. Orbiculoidea pleurites. Meek.

Oblong elliptical, apex of ventral valve near border, depressed, ventral valve discoid with a deep depression posteriorly. Length nearly one inch. Shale over congl, I.

II. Fam. Lingulidæ.

Genus Lingula. Characters of family.

Sp. 1. Lingula waverlyensis. Herrick (L. scotia)

Large species of sub-triangular form and distant raised concentric striæ.

Sp. 2. Lingula membranacea. Win.

Medium size, oblong, length to width as 12 to 6, beak rather acute. Above congl, II.

Sp. 3. Lingula gannensis. Her.

Medium size, oblong, length to width as 11 to 6, beak quite obtuse. Above congl. II.

Sp. 4. LINGULA ATRA. Herrick. (Described beyond)

Medium size, oblong, length to width as 9 to 5, beak larger than a right angle. Below 2d fall, Cuyahoga Valley.

Sp. 5. LINGULA CUYAHOGA. Hall.

Medium size, elongate oval, length and width as 11 to 6, beak nearly a right angle. Below 2d fall, Cuyahoga Valley.

Sp. 6. LINGULA MEEKI. Herrick. (Described beyond.)

Medium size, rather broadly oval or lepidiform, length to width as 12 to 8.5. Below 2d fall, Cuyahoga Valley.

Sp. 7. LINGULA MELIE. Hall.

Small acutely oval, length as 12 to 8, beak acute, with a depressed median line extending from the beak.

Shale above Berea grit.

We thus have an unusually large number of species, when it is remembered that the vastly thicker Chemung group in New York has not furnished a single species. (We have found a poorly preserved Lingula in Chautauqua Co., however.)

A″. ARTHROPOMATA.

Valves thick, unlike, with hinge-teeth.

I. Fam. TEREBRATULIDÆ.

Shell puctuate under a lense, more or less ovoid, smooth or striate, with a circular perforation of the the beak of ventral valve. Dorsal valve with an internal loop. Genera *Terebratula*, *Cryptonella*, *Centronella* only distinguishable by internal characters.

II. Fam. RHYNCHONELLIDÆ.

Shell not punctate, more or less triangular in outline and longitudinally plated, beak with a foramen.

Genus *Rhynchonella*, characters of the family.

III. Fam. ATRYPIDÆ.

Shell fibrous, beak with no area, not strongly plaited.

Genus *Atrypa* with radiating irregular striae.

IV. Fam SPIRIFERIDÆ.

Form various, usually with strong radiating plicæ, and extended hinge line. Internally dorsal valve with calcareous coiled arm supports.

1. Genus *Spirifer*. Elongate transversely, hinge-line longest lateral dimension, radiatingly ribbed or plicate, somewhat tri-lobed.
2. Genus *Syringothyris*. Like Spirifer, with fold and sinus smooth, area of ventral valve high, area with a perforated deltidium leading into a funnel-like projection into the interior.
3. Genus *Spiriferina*. Small spirifers with few plicæ and a prominent partition in the ventral valve.
4. Genus *Martinia*. Hinge-line shorter than greatest width, surface spiny and concentrically grooved.
5. Genus *Cyrtina*. Like Spiriferina but with very high ventral valve, prominent deltidium closing foramen.
6. Genus *Athyris*. Transversely oval, concentrically striate, area obsolete, beak perforate, spires as in Spirifer.
7. Genus *Rhynchospira*. Surface striate or plicate.

V. Fam. STROPHOMENIDÆ.

Shell transversely oblong, with long hinge line and small areas, generally plano- or concavo-convex.

1. Genus *Orthis*. Hinge shorter than width, radiately striate, biconvex.
2. Genus *Hemipronites*. Concavo-convex, hinge nearly as long as greatest width, area of ventral valve narrow, with deltidium, radiating striæ.
3. Genus *Strophomena*. Depressed, concavo-convex, area on both valves, radiating striæ.

V. Fam. PRODUCTIDÆ. Concavo-convex, with straight hinge, generally shorter than greatest width of shell, surface or hinge with long spines, surface porous.

1. Genus *Productus*. Whole surface with spines.
2. Genus *Chonetes*. Spines restricted to the hinge.

Genus CHONETES.

A. Of large or medium size, gently convex.

a. Surface marked by over 100 ribs.

1. C. MULTICOSTA.
2. C. ILLINOISENSIS.

b. Surface marked by 40-60 ribs.

3. C. LOGANI.

B. Very convex, of medium size.

4. C. TUMIDUS.

C. Of rather small size.

a. Surface with over 50 rounded ribs, hinge with about six oblique spines.

5. C. PULCHELLA.

b. Fewer striae, which are sharply raised, four oblique spines.

6. C. SCITULA.

The typical form of C illinoisensis occurs at the very top of the series. A closely allied form, perhaps C. multicosta appears about seventy feet below conglomerate. C. logani is ubiquitous while C. tumidus and C. scitula belong upon the same horizon as C. multicosta. C. mesoloba must be excluded from the list.

Genus PRODUCTUS.

I. Species of large size (over ¾ inch.)

A. Marked by fine, wavy, fasciculate radiating costæ.

1. P DUPLICOSTATUS. Win.

B. Marked by strong, radiating (and concentric) costæ.

B1. Strongly pustulose.

(?) 2. P. NEBRASCENSIS.

B2. Not strongly pustulose.

* Length over one inch.

† Costæ distant,

3. P. RARICOSTATUS. Her.
(= P. dolorosa. Win?)

†† Costæ closely set.

a. Ventral valve tumid, strongly arched over the hinge.

4. P. SEMIRETICULATUS.

b. Ventral valve moderately tumid, less strongly arched over the hinge.

5. P. NEWBERRYI. Hall.

**. Length less than one inch.

a. With very coarse and irregular costæ, very strongly arched.

6. P. ARCUATUS. Hall.

b. Striæ finer and more regular, less strongly arched.

7. P. FLEMINGI. Var.

II. Of small size, (mostly under ½ inch.)

A. Marked only by fine dichotomizing striæ.

8. P. GRACILIS. Win.

B. Marked with fine concentric striæ and irregular coarse pustulose ribs.

a. Very tumid with numerous spines on the ears, not strongly pustulose.

9. P. RUSHVILLENSIS. Her.
(= ? P. morbillianus. Win.)

b. Surface pustulose, spines scattered.

10. P. SHUMARDIANUS.

c. Beak truncated, much as above.

11. P. CURTIROSTRIS. Win.

C. Surface slightly convex, with nearly equal radiating and concentric striæ.

12. P. NODOCOSTATUS.

This list might be extended but some uncertainty would be introduced. The above species can be recognized with tolerable certainty. No. 1, occurs in division III, P. nebrascensis is perhaps not found in the the Waverly, the species so identified being possibly peculiar forms of P. newberryi. P. semireticulatus occurs in the upper part of division III, while its close ally, P. newberryi belongs in a lower zone in division I, but the two species seem to pass into each other in the northern part of the state. P. flemingi, var, burlingtonensis H, is from the uppermost horizon of division III. P. rushvillensis and P. shumardiana are very closely related, though the former is from the highest horizon of divison III and the latter seventy feet below conglomerate II. P. raricosta is known only thus far from below the last mentioned horizon.

Genus RHYNCHONELLA

It is not at present possible to catalogue the Rhynchonellidæ of the Waverly with any degree of success. Three types are easily separable.

A. Large species with three to four plicæ on the fold and sinus.

1. R. SAPPHO.
2. R. SAGERIANA.

B. Rather large species with five to eight plicæ on the fold and sinus.

a. Abrutly deflexed around the front.

3. R. MARSHALLENSIS.

b. 4. R. COOPERI.

C. Smaller species with two to four sharp plicæ on the deep fold.

5. R. CONTRACTA.

D. Small spcies with slight or no fold.

6. ?

LINGULA ATRA, Sp. n.

(Plate X, Fig. 30.)

Ventral valve rectangularly sub-elliptical, length to width as 9 to 5, sides parallel, front margin truncate, cardinal slopes forming nearly a right angle, unbonal region rather distinctly convex, triangular area from front to beak flattened, lateral aspects gently sloping, dorsal valve

less convex and with a rounded inconspicuous beak; surface marked by numerous rather distinct and unequal concentric lines. Length, 16 mm: width, 10.5 mm. The epidermis is of a deep black color in our specimens, but this may be due to the nature of the shale.

In form our species closely resemble L. punctata of the Hamilton but has very different surface characters. It needs no comparison with other Waverly species, being much shorter proportionally than either of the quadrangular species.

Quite abundant above the juncture of the Little Cuyahoga with the Cuyahoga river, where it is associated with L. cuyahoga and L. meeki.

LINGULA GANNENSIS, Sp. n.

(Plate III, Fig. 2, 3.)

Shell elliptically subquadrate, length and breadth as considerably less than two to one (as eleven to six); lateral margins nearly straight and parallel, anterior margin sub-truncate, with rounded angles; beak rather acute, with a faint (internal ventral) ridge extending forward upon the mesial prominence; rostral margins nearly straight.

Ventral valve with a prominent beak, the rostral margins meeting at nearly a right angle; dorsal valve rather shorter and more obtuse. The valves are evenly convex, slightly flattened toward the front by a plane which does not extend to the middle of the longer diameter. The surface of both valves is ornamented by numerous, sharp, concentric striæ. Length of ventral valve 22, breadth 12 mm.

This species resembles in size and form Lingula punctata, H., of the Hamilton group but does not share its surface structure. In some respects L. membranacea, Win., is similar, but that species is proportionally longer and more strictly quadrate.

From Gann, Knox Co., O., in red ferruginious band in the freestone 50 feet above the river below the dam. In the freestone of the middle division of the Waverly near division III.

LINGULA MEMBRANACEA, Win.

(Plate III, Fig. 4.)

This species occurs about 60 feet above conglomerate II, four miles south-west of Loudonville. It is thus not much above our Lin-

gula gannensis which greatly resembles it. That species, however, is much shorter and has a different surface structure. The surface in the present species is very finely striate and usually also possesses the coarser folds of growth. Length of ventral valve, 20 mm., width 10 mm. Meek's figure of the dorsal valve in the Ohio Palæontology is slightly too oblong and not rounded enough at the front,

LINGULA MEEKI, Sp. n.

(Plate X, Fig. 31.)

Shell of medium size, ovate, rather attenuated toward the beak, greatest width near the front, lateral margins gentle curves, front a regular curve, beak rather prominent, general surface depressed convex, marked with the usual concentric striæ.

Length, 13 mm., width, 7.5 mm.

Different specimens differ in the amount of attennation of the beak but it cannot be certainly determined which specimens if any are dorsal valves. This form is somewhat abundant in the Cuyahoga valley with L. cuyahoga, L. atra, etc.

LINGULA WAVERLYENSIS, Sp. n.

(Plate III, Fig. 1.)

Lingula scotica, MEEK, Pal. O. vol. ii., p. 276. Cf., L. scotica, var. nebrascensis, MEEK, Pal. Neb., p. 158, and L. scotica, HERRICK, Bul. Denison Univ. vol. ii., p. 144, also L. scotica, DAVIDSON, Carb. Mon, p. 267, Supl.

It is quite obvious that there are two or more forms related to the European L. scotica in American rocks, The coal-measure forms vary considerably yet apparently differ from the Waverly specimens. True, the latter are found in the upper third of the series and may be regarded as precursors of L. scotica, but they none the less need to be distinguished. The specimens are found in the shale above conglomerate II, with Orbiculoidea pleurites with both valves in opposition.

Shell sub-trigonal, compressed; front margin subtruncate, rounded toward the sides which are nearly straight and converge in the ventrat valve at an angle of about 120° to the rather acute but not attennated beak, while the shorter dorsal valve has a bluntly rounded beak.

Surface of both valves covered by minute, numerous regular striæ upon a plane surface; toward the front the striæ may become irregular and similar to the usual markings in the genus; there are also traces of radiating grooves. The striæ are much finer and less numerous than in L. scotica. Our specimens exceed in the closeness of the striæ the example figured by Meek. Length of dorsal valve, 20 mm., width of same valve, 19 mm.

Blue shale above conglomerate II, Newark, O.

ORBICULOIDEA PLEURITES, Meek.

(Plate III, Fig. 5, also vol. III, Plate VIII, Figs. 13, 14.)

Shell large, plano-convex, elliptical. Ventral valve in perfect specimens nearly a true ellipse or slightly oval, strongly convex, greatest elevation near the middle, beak sub-terminal or terminal, depressed, length to width as 25 to 22, surface marked by numerous, rather strong concentric lines which may be quite irregular. Dorsal or under valve flat or slightly concave with strictly concentric striæ and marked by a deep oval impression, which extends one-third the diameter of the shell. Length of a large specimen, 25 mm., width, 22 mm., height, 45 mm.

It was long suspected that the large dorsal valves associated with O. pleurites were of that species before the discovery of two valves in opposition settled the matter.

Shale above congl. II, Newark and the same horizon near Gann, Knox Co.

PODUCTUS RARICOSTATUS, Sp. n.

(Plate III, Fig. 19; Vol. III, Plate III, Fig. 28, ?)

Ventral valve of nearly the size and proportions of P. newberryi in its smaller forms known as P. annosa. Sub-quadrate, with regularly arching surface and acutely pointed somewhat projecting and incurved beak, angles acute, sub-elevated, mesial depression slight or none; marked by distant rounded irregular ribs, fine numerous concentric striæ and variable concentric grooves; spines few, scattered. Dorsal valve apparently the same as in the last volume figured as possibly P. lachrymosus var; suface plane to a short distance from the margin where rather suddenly reflexed to correspond with the opposite valve,

surface ornamented along this marginal portion as in opposite valve, the remainder only by concentric striæ and folds and the pustules bearing scattered spines. Width. 38 mm., length, 34 mm., convexity of ventral valve, 10 mm.

Near calcareous concretionary zone at Moot's run. It is is possible that this is Winchell's P. dolorosa which we have not seen. There is reson to suspect that the specimens hesitatingly referred in vol. iii, to P. lachrymosus, var. stigmarius, H. are extreme phases of the present species.

PRODUCTUS NEWBERRYI, H.

(Plate X, Figs. 24, 35.)

A very large suite of this species from Bagdad, Weymouth, Medina, Lodi, Burbank, and Cuyahoga Falls present a close agreement except that the specimens from the shales are smaller and less fully developed. From P. semireticulatus as seen in the coal measures it differs constantly in the less elevated and arched ventral valve and less perfect development of the concentric markings. It seems to differ from the form identified with P. semreticulatus in central Ohio. The tubular spines are strong and curved, being most abundant on the ears of the ventral valve.

Length of a ventral valve, 33 mm., width. 47 mm., height of valve, 18 mm.

This species does not seem to descend much below 100 feet below the conglomerate.

PRODUCTUS (NEWBERRYI, var.?) ANNOSUS, var. n.

(Plate III, Fig. 17.)

Shell sub-quadrate in outline, moderately convex, length somewhat less than the width; ventral valve moderately convex, convexity less than half the length, greatest about half way from the front margin to the moderately elevated arched beak, which projects but little beyond the hinge; a rather shallow, but distinct mesial sinus extends to near the umbo; shell rapidly depressed toward the small upturned ears which are rounded slightly at the extremities; hinge nearly as long as the entire width; surface marked by varicose and rather strong

radiating costæ which bifurcate irregularly and are pustulose by the prominences bearing the long spines, which latter cover the entire surface though much more numerous upon the ears; surface also ornamented by very numerous minute concentric striæ, also in certain conditions of preservation by the usual fine pores; surface rarely also rendered irregular by large concentric folds.

Dorsal valve plane nearly to the margin, then suddenly deflected to apply to the marginal portion of the ventral valve, marked like the opposite valve, but less distinctly upon the plane portion. Transverse diameter of specimen of medium size, 26 mm., length, 21 mm., convexity, 8-9 mm., projection of beak beyond hinge, 2 mm., nine costæ in distance of 1 cm. at front; depression of dorsal valve (nearly at right angles to plane of valve) at front, 6 mm.

A considerable suite of this species was collected at Alexandria, O., in light silicious flags some distance below the concretionary layer at Moot's run, in connection with P. shumardianus of the same type as found in the concretions.

In many respects this form resembles P. newberryi, Hall. Direct comparison with specimens from the original locality make it advisable not to separate this as a distant species.

PRODUCTUS DUPLICOSTATUS, Win.

(Plate XI, Figs, 26, 29.)

"Shell rather large, with sub-circular outline, ventral valve very ventricose and greatly arched, with steep slopes to the right and left margins, not enlarged at the aperature and entirely destitute of mesial sinus; marked with numerous interruptedly and irregularly striate sinuous ribs, which dichotomize one or twice in the middle region of the valve, and toward the front resolve themselves each into a fascicule of three or four smaller ribs, themselves raised into a wider rib-like elevation around the anterior margin. The tubular spines are scattered over the whole exterior, but become much more numerous at the commencement of the marginal cosate ridges. The whole exterior of the cast is marked also by oblique punctations, which are placed mostly in irregular lines between the ribs. Length,.....1.19, breadth, 1.24, convexity of ventral valve, .58, number of marginal ridges. 15-20."

This species is apparently, frequently identified with P. cora to which it has a superficial resemblance. Near conglomerate II, to P. arcuatus layer, Knox and Licking Counties.

The ventral valve of P. duplicostatus was seen in connection and is nearly flat with a slight depression of the umbonal region but without the sharp flexture near the front seen, for example, in P. flemingi which is quite similar otherwise. The surface characters resemble those of the ventral valve, the whole surface being, however, concentrically wrinkled.

PRODUCTUS RUSHVILLENSIS, Sp. n.

(Plate III, Fig. 15.)

Shell small, hemispherical, very tumid but abrubtly flexed near the middle so that the outline of ventral valve as seen from the side is formed of two gentle curves meeting at an angle less than a right angle near the middle; length and breadth about equal; hinge nearly equal to greatest width, sides intersecting the ears at nearly a right angle; beak projecting but little beyond the hinge; umbo rather narrow; in larger individuals a slight mesial flattening, but no sinus. Surface marked by few more or less distinct rounded ribs which are irregularly nodose, but simple and tend to disappear near the margin, and by concentric striæ and folds which form strong plications upon the ears; spines very long, as long as the entire length of shell on the ears where they are numerous; surface of the cast sharply pitted and near the beak furrowed longitudinally. Length of medium sized specimen, 10.5 mm., width, 11 mm., height, 8 mm. Number of radiating plicae 20. This species resembles somewhat P. wortheni of the Keokuk, but is still more like P. costatulus H. from the Chemung. Some forms of P. lachrymosa approach quite nearly. Of the described Waverly forms none seem to require comparison except P. shumardianus of which the present species is the lineal descendant apparently.

Subsequent study shows the dorsal valves to be rather strongly concave about one-fourth the height of the ventral, then nearly flat except for a gentle depression in the umbonal region and marked by indistinct ribs below and everywhere by concentric striæ and folds.

With Phillipsia serraticaudata, Productus burlingtonensis, etc. (about 70 feet above horizon of P. arcuatus) at Rushville, Newark, Loudonville, etc.

PRODUCTUS NODOCOSTATUS, Sp. n.

Shell of rather small size, sub-circular in outline, only moderately convex.

Ventral valve as wide as long; hinge line equalling seven-tenths the greatest width; ears small, triangular; beak slightly projecting, acutely prominent, sloping sharply to the flat ears, sloping gently to the front margin; surface covered by numerous, coarse, rounded, rarely bifurcating radiating costæ, rendered nodose by equally coarse, concentric wrinkles. A few spines could be detected on the ears in some specimens, but in others they are obscure. If this is a Productus it is quite remarkable in its surface marking and also in its slight convexity. Width, 12 mm., length, 11 mm., convexity, 5 mm., or less. We have been unable to compare specimens of P. morbillina, Win. which seems to resemble it. From the upper layers at Rushville, about 100 feet above conglomerate II.

RHYNCHONELLA CONTRACTA, H.

(Plate XI, Fig. 21.)

Since the last volume of the bulletin was published, we have had opportunity to compare carefully and minutely specimens in the same state of preservation, preserving both valves, teeth and all details from the Chemung of Chatauqua Co., and the Waverly of Medina Co., and find the most perfect identity of characters. There can be no doubt of the identification. The same species is also doubtfully known from the Cuyahoga shales.

RHYNCHONELLA MARSHALLENSIS, Win.

This is the common species in the middle Waverly, but occurs rarely seventy feet below conglomerate I near Granville, and in Ashland county. Whether this species is but a modification of R. sappho must be left undecided. The specimens referred to R. sappho in the last paper are more closely allied to the present form than then supposed.

RYHNCHONELLA, Sp.

(Plate XI, Fig. 22.)

We have a small specimen from Lodi which seems to differ from all the Waverly species, though almost a minature of R. marshallensis.

The very convex and broad form with numerous obtuse or rounded plicæ and the flexture at the front all suggest that species.

HEMIPRONITES CRENISTRIA.

The variation seen in this species is extreme and it will not be attempted to carefully illustrate these. Plate II, Fig. 1, illustrates the typical variety at seventy to one hundred feet below conglomerate I. Plate III, Fig. 12, displays the characters of the rounded form encountered above conglomerate II, where it is associated with a deltoid form even larger than that figured. In the shales sharper striations are preserved. Fig. 5, of Plate II illustrates the appearance of the young as seen at Moot's run.

ATHYRIS ASHLANDENSIS, Sp. n.

(Plate III, Fig. 6.)

Closely resembling in ascertainable characters *A spiriferoides* from the Hamilton, but differing in that the mesial sinus of the dorsal valve is less abruptly elevated at the front. Width of dorsal valve, 43 mm., height, 32 mm. Several valves in a more or less imperfect condition have been collected at Moot's run and in Ashland Co.

TREBRATULA (?) INCONSTANS, Sp. n. (Cf. T. LINCKLÆI, H.)

(Plate XI, Fig. 18; Plate III, Figs. 8, 9.)

Shell sub-ovate, broadest below the middle, length less than one and three-fourths the breadth, moderately gibbous, thickness greatest considerably above the middle, lower outline generally distinctly truncate.

Ventral valve gently arched until near the beak where more rapidly curved, greatest width at the hinge margins at nearly one-half the height.

Dorsal valve less arched, most prominent a short distance below the beak, surface with greatest convexity along medium line and curving gently to the sides, angle of beak about 112°, shell punctate, cast with radiating ridges, shell marked by concentric lines of growth. Length of small, perfect specimen, 10 mm., width, 8.5 mm., thickness, 5.5 mm. Largest specimen seen, length 31 mm., width, 24 mm.

Although very constant in form, this species varies greatly in size. The small forms resemble T. lincklæi, H. It differs, if at all, in having the anterior truncation rather more pronounced. The resemblance approaches identity.

Moot's run, 70 feet below congl. I, Ashland Co., 70 feet below congl. I, and Lodi, Medina Co.

RHYNCHOSPIRA (?) ASHLANDENSIS, Sp. n.

(Plate III, Fig. 16.)

A small Rhetzia-like species from the horizon seventy feet below conglomerate I, occurs near Lyon Falls, Ashland Co.

Shell small, broadly sub-oval, with the greatest convexity of the valves above the middle, and the beak of the ventral valves produced beyond its fellow, perforate.

Ventral valve with a strong, narrow, mesial elevation proceeding from the beak to the front where it gradually expands, passing into the general surface at the front which is sinuous; lateral surface depressed, beak strongly projecting, length and width about equal, surface marked by about twenty rather abrubtly elevated simple ribs, separated by curved depressions. Dorsal valve wider than long, with a shallow mesial sinus which widens below, lateral surfaces convex. Length, 6.5 mm.

As nothing is known of the interior the generic reference is but provisional.

SPIRIFER BIPLICATUS, Hall.

(Plate II, Fig. 8.)

Examination of a large suite of specimens happily removes all doubt as to the position and specific identity of this species. The species has been peculiarly unfortunate in the illustrations hitherto given with the descriptions.

Meek's figure in the Ohio Palæontology is quite unrecognizable. There is comparatively little variation in our series. Meek's description applies well but it is unusual for more than four plicæ to occupy the fold and these are distinctly paired. The mucronate hinge is also constant and forms an easy distinguishing character from S. striatifor-

mis with which it is associated. Our specimens average less than one inch in extreme width. The area of the ventral valve is rather low and arched and striate parallel to the hinge line.

SPIRIFER MARIONENSIS, Shum.

A comparison of *Spirifer marionensis* and *S. biplicatus* is rendered the more necessary because of their close resemblance and importance as marks of given horizons. The following notes are the result of a careful study of a large suite from all parts of the state.

The ventral valve of S. marionensis is more evenly and strongly convex and toward the hinge is more uniformly gibbous, it also projects farther over the hinge, thus the beak of S. biplicatus seems more acute; the hinge line is more elevated and strongly arched in S. marionensis, while in the other species its sides are approximately parallel until the vicinity of the beak is reached, the area is strongly striate perpendicularly in S. biplicatus, while in S. marionensis there is also an evident transverse system and a thick ridge below; in both species there are long sharp spines upon the hinge angles which may exceed one-fourth the width of the body of the shell; the plicæ are not strongly dichotomous in S. marionensis except near the beak, while S. biplicatus tends to develop a pronounced dichotomy or grouping in the ribs; the sinus is more distinct and narrower below in S. marionensis; the cast in S. marionensis is pustulose about the umbonal region while the rostral cavity is more deeply excavated though the teeth seem less prominent; other minor differences are observed in the comparison of the specimens.

The dorsal valves differ in proportions, S. marionensis being rather shorter and having in many cases a slight sinus instead of a fold or, at any rate, no prominent elevation toward the front; the fold in S. biplicatus is generally well-marked and often high and is further distinguished by the marked dichotomy of the plicæ.

Spirifer marionensis marks a horizon some seventy feet below conglomerate I, and is known to extend along this line from Richland county to the Ohio river at Portsmouth and Sciotoville. Its absolute horizon is not seen in the northern part of the state, but some of the associated fossils seem to occur at the base of the exposure at Lodi with Sp. biplicatus and Entolium aviculatum, It is not improbable that S. biplicatus is a lineal descendant of the older form and it is

found in the southern and central part of the state at from 70 to 100 feet above conglomerate II with no connecting or introducing forms, it also occurs in the Cuyahoga shales from 100 to 150 feet from the top.

SPIRIFER (MARTINIA) TENUISPINATUS, Sp. n.

(Plate II, Fig. 4.)

Shell of moderate or small size, strongly convex and arched, somewhat wider than long, with very short hinge and rounded angles; ventral valve tumid, especially in the umbonal region, with an undefined sinus extending from the produced basal margin half way to the beak; general outline of valve rhombic ovate, the rounded hinge extremities being slightly above the middle of the height; suface marked by numerous (about 20 in adults,) rounded concentric folds and very fine somewhat irregular radiating striæ (in the cast), the summit of the folds ornamented by numerous pointed perpendicular spines in one row. The cast is marked by the impression of a median plate extending one-third the height upon the umbo. Height, 19 mm., width, 21 mm.

The species is especially characterized by the very high incurved beak, proportions, and surface characters. From S. hirtus if differs in its relatively greater height and larger size. See Plate iii, Vol. iii, In the same way it differs from S. pseudolineatus. It is much more nearly like S. setigerus, H. from the Chester, from which it is strangely dificult to separate it. The beak is higher, however, and the concentric wrinkles more marked. Spirifer præmatura of the Chemung may prove more nearly allied than appears from published descriptions.

[Compare Pal. N. Y., Vol. IV., p. 250, et seq.]

SPIRIFER DELTOIDEUS, Sp. n.

(Plate II, Fig. 7.)

Our material is still too imperfect to make possible a complete characterization of this species referred to on page 45, Bul. Den. Univ. vol. iii., but the examination of additional material leaves no doubt as to the specific difference of the form from S. striatiformis and S. marionensis. From the last mentioned species it obviously differs in its more triangular outline and rounded ears. as well as its more elevated

and finely striated mesial fold. From S. striatiformis it also differs in the two first mentioned particulars.

Shell of medium size, quite gibbous, triangular in outline, hinge equalling the extreme width; anterior margin angulated in the middle, forming with the hinge roughly an isosceles triangle of 45°; hinge apparently not, or but slightly, mucronate. Dorsal valve prominently convex along the longitudinal axis, rather strongly arched; beak moderately prominent; fold triangular, rather high, sides of shell sloping rapidly from it toward the sides. Surface covered by nearly sixty small rounded, persistent striæ, which rarely bifurcate near the front. From eight to ten striæ fall upon the fold which in spite of its prominence (and because of the similar convexity of the valve) is poorly defined. Ventral valve very convex, provided with a deep, triangular, but narrow sinus and sculptured as the dorsal valve. Width of dorsal valve, 37 mm., height, 29 mm.

All our specimens are casts of separate valves in the sandy parts of conglomerate I. There is reason to accept the suggestion made in the last volume that this species forms a link between the S. marionensis and S. striatiformis.

ALLORISMA NOBILIS, Dekou.

[See Bul. Den. Univ., Vol. iii, p. 71.]

Additional specimens of this fine species enable us to add the following facts:

There is a considerable range of variation. The shortest specimen seen measures 92 mm. in length, 25 mm. in height at the umbo. The beak is strongly incurved and is more produced than represented in Plate X, Fig. 5, of vol. iii. The effect of this is to make the anterior margin somewhat curved and less extended than there drawn. The surface is marked by very fine thread-like concentric striæ as well as the coarser ones and also by the granular radiating striæ characteristic of the genus, the later being rarely preserved.

ALLORISMA CUYAHOGA, Sp. n.

(Plate X, Fig. 34.)

Shell of medium size, quadrately sub-elliptical, the length equal to twice the height, moderately convex; height nearly equal at both ends; posterior margin obliquely truncate, as is the front; hinge mar-

gin slightly concave, front margin nearly straight, curved nearly equally at either end; umbo moderately prominent, beaks incurved over the anterior third; surface evenly convex, post-umbonal slope with a slight secondary ridge, escutcheon and lunule well marked. Length, 39 mm., height at beak, 24 mm. Flags below second fall at Cuyahoga river.

This species resembles A. winchelli greatly but is much shorter proportionally and has a very different front margin.

ALLORISMA CONSANGUINATUS, Sp. n.

(Plate XI, Fig. 13.)

Shell rather under medium size, quadrately sub-elliptical, the length equal to twice the height, moderately convex; posterior margin obliquely truncate, short, abrubtly rounded below; front margin rather broadly rounded, greatest projection above the middle; ventral margin a broad gentle curve; hinge line nearly straight; umbo very prominent, beak near the anterior third; post umbonal slope sulcate; surface marked by very coarse, strong, concentric folds.

The peculiarity which separates this from all other members of the genus in the Waverly is the narrowness of the posterior portion and the strongly concave post-umbonal surface. From A. winchelli, its nearest neighbor, it differs in the fuller and less acute curve of the anterior, which sweeps upward nearly to the hinge.

Shales over congl. II. Length, 25 mm., height at beak, 13 mm., height at posterior margin, 9 mm.

LEIOPTERIA NASUTUS, Sp. n.

(Plate XI, Fig. 30.)

This species closely resembles L. ortoni and may best be described comparatively. The body is much more oblique and the posterior wing, therefore, much restricted, the anterior ear is prolonged and rounded at the extremity, beak behind the first third, acute, Length, 10.5 mm., height, 6 mm. Bagdad, Medina county, apparently nearly on the same horizon as L. ortoni.

AVICULA (LEPTODESMA) SCUTELLA, Her.

(Plate V, Fig. 6, Vol. III. Plate IV, Figs. 16, 17.)

[See Vol. III, p. 59.]

Shell small, obliquely semi-oval, hinge-line equalling the greatest length, height and length nearly equal; posterior wing rather large flat, posterior margin slightly concave, nearly at right angles to hinge-line; anterior ear very small, sub-acute, depressed, nearly covered by the acutely projecting sub-anterior beak; umbonal region abrubtly convex, rapidly expanding toward the broad lower portion of the shell, which is marked by concentric striæ. Freestone of middle Waverly. Length of hinge, 6 mm., height, 6.5 mm.

AVICULA ? SUB-SPATULATA, Sp. n.

(Plate V. Fig. 11; Vol. III, Plate III, Fig. 6.)

This species which is quite common in the lower part of division iii at Newark seems to differ widely from any associated species and, though its hinge is unknown, its general form associates it with carboniferous species referred to Avicula. Shell slightly oblique, forming an angle of about 25° with a line perpendicular to the hinge; hinge short, contained in the height about two and one-half times; posterior wing flat, obtuse, rather small, anterior ear very small almost covered by the sub-anterior beaks; greatest anterior projection of anterior margin near the middle of the height, posterior outline gently concave above, convex below; surface slightly convex, grooved and striate.

Length of hinge, 85 mm., oblique height along umbonal prominence, 21 mm., greatest length, 15 mm.

EDMONDIA SULCIFERA, Sp. n.

(Plate V, Fig. 1, 2.)

This fine species is most nearly related to E. burlingtonensis, but becomes much larger than the Ohio representatives of that species, the form also is less oval and the anterior hinge angle more prominent.

Shell longitudinally sub-oblong, once and a half as long as high, moderately convex; posterior margin a very slight curve oblique to the rather long cardinal line, which extends in front of the beak to meet the more rapidly curved anterior margin; lower margin nearly

straight, passing by an abrubt curve into the posterior side, more slowly curving to the front; greatest convexity above the middle; umbo prominent, projecting; beak small, close to the hinge, situated about one-fourth from the front; surface with fine concentric striæ and deep equi-distant grooves about fourteen of which occur on a large specimen; hinge with a strong posterior tooth.

Moot's run, seventy feet below congl. I.

SPHENOTUS CONTRACTUS, W. W.

(See Vol. III, p. 69.)

Winchell in 1865 identified this species with his own Edmondia bicarinata. Originally this species was supposed to have come from the equivalent of the mill-stone grit. Cf. also Cypricardia securis Win. Proc. Acad. Phila. 1870, p. 255.

Genus Spathella. H.

"Shell equivalve, inequilateral, wider behind, transversely sub-cylindrical. Anterior end short, narrowly rounded. Beaks sub-anterior, small. Umbonal slope rounded or sub-angular. Surface marked by concentric striæ, which are often more or less lamellose. Interior unknown."

SPATHELLA VENTRICOSA, W. and W.?

(Plate IV, Fig. 20.)

Our specimens do not fully agree with the figures of "Orthonota ventricosa," but there seems to be a considerable range of variation, and as that species occurs in the Kinderhook group of Illinois, it seems likely that ours is closely allied if not identical.

Freestone of middle Waverly.

MYTILARCA FIBRISTRIATUS, W. and W.

(Plate IV, Fig. 21.)

The original description reads as follows:

"Shell elongate oval, alternate at the beaks, more ventricose below, extremely compressed toward the extremity of the hinge and posterior margin. Beaks terminal, small and pointed; hinge-line straight,

about half as long as the shell. Postero-dorsal margin gently curved toward the sharply-rounded posterior extremity; ventral margin gently arcuate, more strongly rounded toward the beaks, a little below which the ventral surface is somewhat protruded and the margins slightly gaping, forming a distinct byssal opening. Surface marked by fine, closely arranged, radiating striæ, which become faint or obsolete on the antero-ventral portion."

Moot's run, 70 feet below conglomerate I.

MYTILARCA OCCIDENTALIS, White and Whitfield ?

Plate XI, Fig. 1.)

The description of this species is, like most of those in the paper referred to, very equivocal, without measurements and almost devoid of comparative proportions.

"Shell extremely elongate, very ventricose, the diameter through the valves on the upper third of the shell as great or greater than the breadth from the ventral to the dorsal margins, becoming more compressed toward the posterior, which is abrubtly rounded. Dorsal line nearly straight, extending about two thirds the length of the shell. Ventral margin gently acuate to near the anterior where it slopes abrubtly to the beaks. Beaks terminal, obtusely pointed, umbonal prominences sub-angular. Surface marked by closely arranged, concentric lamellose lines, parallel to the margin of the shell."

Our species differs from M. fibristriatus in being more expanded above the umbonal prominence posteriorly, the hinge being longer and the greatest posterior projection lower. Length, 47 mm., height, 17 mm. Medina county, O.

LYRIOPECTEN NODOCOSTATUS, Sp. n.

(Plate XI, Fig. 5.)

Shell large, longitudinally broadly elliptical; height somewhat less than the length, margin regularly rounded. Valves similar; right valve flat. Hinge-line straight, length over two-thirds the entire length of the shell. Anterior ear small, somewhat acute, rather indistinctly marked off from the valve, but apparently without deep byssal sinus; anterior ear much larger and well defined. Surface marked by about

45–50 strong very nodose radii separated by a shallow groove and one, or occasionally two, unornamented ridges.

Our specimens are all imperfect, but a nearly complete right valve indicates that the outline must agree closely with that of L. interradiatus, H. from the Hamilton group, with which it agrees in size. The surface structure serves to distinguish it from other members of the genus. Height, 37 mm., length, 43 mm.

Concretionary zone about seventy feet below conglomerate I, in Licking and Richland counties.

PTERINOPECTEN CARINIFERUS, Her.

(Plate V, Fig. 12.)

Additional specimens show that the form of the left valve is inconstant in one particular. The anterior ear occasionally does not correspond to its fellow in outline but is continued from the anterior extremity of the hinge nearly at a right angle to point of union with the body. The ear therefore is nearly a right-angled triangle, but is marked by the impression of the margin of the corresponding ear of the right valve. This must be regarded as the typical form, but is rarely seen as in most left valves the byssal sinus is well-marked. Length, 17 mm., height, 14 mm., distance between radiating striæ nearly 1 mm.

This species is quite abundant in Ashland Co., about seventy feet below conglomerate I, and also occurs at Lodi in the concretions at the very base of the exposure.

PTERINOPECTEN (?) ASHLANDENSIS, Sp. n.

(Plate XI, Fig. 4.)

Known only from fragments of the left valve. Shell triangularly sub-elliptical in outline, somewhat oblique, length somewhat greater than the height. Umbonal region narrow, acute, depressed, body rapidly expanding toward the front, ant-umbonal margin concave, long; anterior ear unknown; front margin a gentle curve; post-umbonal margin straight; posterior ear small, flat, obtusely triangular. Surface depressed convex, ornamented by about fifty irregular wavy ribs in pairs, separated by narrow impressed grooves, which are crossed by

concentric, more or less wavy grooves and striations. Length, 25 mm., height, 23 mm.

It is not possible to strictly define this species but it is sufficiently distinct from any of the associated species.

Concretionary shale seventy feet below conglomerate I, near Lyon Falls, Ashland Co.

CRENIPECTEN CANCELLATUS, Her.

(Plate V, Fig. 3.)

[Vol. III, p. 54, Plate XII, Fig. 7.]

Full-grown specimens of this species are less orbicular, and the right valve makes it obvious that our species is not a Lyriopecten but probably Crenipecten, though the hinge is still unknown.

Right valve closely resembling in outline that of Streblopteria media, but less convex and with a larger posterior ear. Surface marked, as in the opposite valve, by sharp, fine, and very numerous concentric and radiating striæ, the radiating striæ becoming very coarse on the anterior.

CRENIPECTEN CRENISTRIATUS, Meek.

(Plate V, Fig 14.)

A considerable suite of specimens permits little doubt that the various forms of large Pecten-like shells of the upper Waverly all belong in the assemblage named as above by Meek. We have not indeed encountered any individuals with the outline as drawn in the Ohio Palæontology, but although these figures are not expressly said to be restorations, yet that this is the case is implied in the following remarks: "It is remarkable in having only a comparatively shallow rounded sinus under the anterior ear of the flat right valve, where it is usually deep and angular in species of this genus, while in the left it is deeper and more angular, *though none of the specimens are in a condition to show its exact form.*"

Considerable variation is encountered in shells from different horizons. Those found only a few feet above conglomerate II most nearly resemble the figures of Meek, but the left valve has the posterior ear more strongly produced and larger, while the anterior ear is much larger and the margin below the sinus is produced and abrubtly angu-

lar, instead of gently curved. Specimens from about 100 feet above conglomerate II have much larger posterior ears but otherwise remain nearly the same. The right valve does not usually have the exceptional form referred to by Meek but posseses the usual strong sinus under the anterior ear. The surface of the valve is less strongly marked than the left which is exquisitely ornamented with alternate radiating and keeled concentric striæ. As we have already proposed the term *granvillensis* for the form first above described, we may suggest *rushvillensis* for the second, since it is there abundant at the top of the exposure. These may be regarded as named varieties or formæ.

GRAMMYSIA OVATA, Sp. n.

(Plate III, Fig. 12)

Shell of medium size, quite ventricose, convexity being considerably greater than the height, and greatest tumidity near the umbo length to height as 80–45; general outline sharply ovate, acute posteriorly; anterior margin short, with a deeply impressed lunule; hinge margin gently curved, escutcheon well defined; lower margin a long sweeping curve passing by a sudden flexture into the dorsal margin produced; beaks incurved almost over the anterior margin; surface striate, Length, 40 mm., height, 23 mm., ventricosity, 26 mm.

Upper part of division III, Newark, etc

GRAMMYSIA FAMELICA, Sp. n.

(Plate VI, Fig. 5.)

Shell apparently never attaining medium size for the genus, suboval in outline, moderately convex; height to length as 11 to 15; greatest convexity near the upper third; beaks very prominent, incurved, situated rather more than one-third the length from the front margin; lower (basal) margin a very shallow curve, meeting the obliquely truncated posterior margin rather acutely and curving more rapidly to the intersection with the anterior margin at about one-half the height of the shell; anterior margin nearly straight or somewhat concave; the escutcheon not distinct, lunule distinct, though short; beak enrolled over the hinge-line which is less than one-half the entire length; post-umbonal slope scarcely defined. Surface marked by

thread-like striæ and rather coarse folds which are most prominent as they cross the antero-umbonal slope. Length 30 mm., height 22 mm., convexity of one valve, 7–9 mm.

This species is unusually short and Schizodus-like and may not be a Grammysia, thongh doubtless falling in the same group with theWaverly species referred doubtfully to that genus by Meek.

Shale below conglomerate I, Granville.

SCHIZODUS (CHEMUMGENSIS, var.) PROLONGATUS, Sp. n.

(Plate VI, Fig 1, also Plate IX, Fig. 20, vol. iii.)

It is only in deference to the opinion of able palæontologists that this form is separated from the typical S. Chemungensis, from which it differs almost solely in being generally somewhat more extended at the postero-basal angle and hence having somewhat more oblique posterior margin. There may or may not be a faint sinus passing upward from a point slightly forward from the posterior angle. Length, 33 mm.,height, 24 mm.

This form is not rare in shales below conglomerate I, at Granville.

SCHIZODUS NEWARKENSIS, Herrick.

(Plate VI, Fig. 6.)

A number of additional specimens of this our largest Schizodus afford opportunity for ascertaining the typical form. As supposed, the original specimen proves to have been considerably distorted, but the species is quite distinctly characterized by the uniformly curved anterior margin which forms nearly a segment of a circle and the convexity of the surface near it as well as the obliquely protruded posteroinferior angle and large size. In outline the species somewhat resembles certain forms of Sc. chemungensis, which, however, never attains anything like the size of the present species. Length, 80 mm.,height, 60 mm. Length, 82 mm., height, 64 mm.

MACRODON NEWARKENSIS, Sp. n.

(Plate IV, Fig. 19.)

Shell of medium size, rather flat, sub-oblong, about twice as long as high, basal and cardinal margings parallel, the former gently con-

vex throughout, not affected by a sinus medianly as usual in the genus; hinge-line shorter than the shell; posterior side slightly oblique forming an angle of about 100° with the hinge; anterior margin apparently meeting the hinge at nearly a right angle; surface depressed posteriorly but elsewhere gently and nearly uniformly convex, marked by both radiating and concentric striæ, the former consisting of minute wavy lines on the post-umbonal space, four or five strong costæ on the umbonal prominence and passing to the postero-inferior angle, and very fine, straight, close radii on the remainder of the shell, the whole being delicately and finely cancellated by concentric striæ.

Perhaps this species most nearly resembles M. tenuistriata of the coal-measures, from which it differs in lacking the sinus below, in the surface markings and outline.

A similar but smaller form is figured by Hall from Bedford, O., but seems to agree with M. hamiltoniæ in markings.

M. chemungensis possesses the sinus and differs in markings. The resemblance to M. micronema, M. and W. * is much more striking apparently, but our shell is larger and less extended. Length 33 mm. height 17 mm. Length of another specimen 41 mm.

Near Newark, O., about 60 or 70 feet above congl. II in our division III.

MACRODON STRIATO-COSTATUS, sp. n.

(Plate VI, Fig. 7; Plate XI, Fig. 37.)

Cf. *Macrodon parvus*, W. and W.]

A small Macrodon of the same group as M. newarkensis is found in shales seventy feet below conglomerate I, in Ashland Co. It is, however, a smaller species and does not have the enlarged striae, on the post-umbonal ridge.

Shell small, transversely semi-elliptical, a little broadest posteriorly, hinge nearly equalling the greatest length; beak about one-fourth from the front, somewhat prominent; anterior outline a gentle curve, beginning at the hinge with a little more than a right angle, it curves more rapidly as it enters the ventral margin which is more or less convex; posterior outline somewhat concave; surface convex about the umbonal region, quite flat posteriorly, marked by strong concentric

*Proc. Acad. Nat. Sci. Phila. 1886, p. 261.

furrows and numerous radiating striæ. Length, 8 mm., height, 16 mm.

Specimens from Licking and Ashland counties agree quite perfectly.

MACRODON, Sp.

(Plate XI, Fig. 28.)

A small species resembling M. delicatus of the coal-me asures differs from all other Waverly species in the strong radiating markings confined to the posterior two-thirds, while the anterior part of the shell is nearly devoid of them. Our specimen is too imperfect to admit of description as the hinge-line appears to be covered or broken away, but the occurrence of the species with Spirifer marionensis at Portsmouth should be noted.

CYPRICARDINIA (MICRODON ?) SCITULA, Sp. n.

(Plate VI, Fig. 8.)

Shell very small, tapezoidal, highest behind, somewhat convex. Anterior margin short, concave, forming with the hinge an angle of about 120°; hinge-line straight, about two-thirds the length; posterior margin nearly straight, meeting the hinge at an angle of over 135°, abruptly curved below; lower margin slightly convex, straigthened in old specimens near the middle. A strong, curved ridge passes from the sub-terminal beak to the postero-inferior angle, middle of valve with a shallow sinus passing to the lower margin in old specimens. Surface ornamented by distant sharply, elevated, rib-like concentric ridges and grooves. Length of largest specimen, 10 mm., height, 5.0 mm. Average specimen, 7 mm. long.

CARDIOPSIS (DEXIOBIA ?) OVATA, Hall.

(Ptate IV, Fig. 6.)

Dexiobia whitei, WIN.

This species has a curious history of which our specimens do not permit us to attempt the concluding chapter. It was described by Prof. Hall in his Iowa report from the Kinderhook group at Burling-

ton, in the following terms: *Cardiomorpha ovata.* "Shell ovoid or subcordiform; valves ovate, slightly oblique, a little longer than wide, very gibbous in the middle and toward the umbo; beaks extended and incurved. Surface marked by numerous fine radiating striæ."

In the Proceedings of the Boston Society of Natural History, Mr. C. A. White described *Cardiomorpha parvirostris* as follows: "Shell sub-circular in outline, slightly inequilateral; valves broadly and moderately convex; base more broadly rounded than the front and oval margins; beaks small, incurved, pointing little, if any, forward. Surface marked by fine radiating lines."

In the meantime Meek and Worthen in Proc. Acad. Nat. Sci., Phila., 1861, (afterwards also in volume ii of the Palæontology of Illinois) had founded the genus *Cardiopsis* upon a species from the same horizon with the following diagnosis: "Shell equivalve, somewhat inequilateral, very slightly oblique, ovate or cordiform, entirely closed; beaks rather elevated, distinctly incurved and directed toward the anterior side; surface marked by radiating striæ or costæ; cardinal margin short and rounding into the posterior border, hinge provided with one or two distinct anterior teeth in each valve, near the beaks."

To the original species C. radiata, Prof. Winchell added three more in 1862, (Proc. Acad. Phila., p. 417.) C. crenistriata differs from C. radiata "only in its striation," and seems to have been reunited with that species by its author, and is omitted from the list published in 1870. Cardiopsis megumbonata scarcely differs and suggest that C. radiata may exhibit considerable variation. C. jejuna, the remaining species, seems quite distinct.

In 1863 Prof. Winchell formed the genus Dexiobia (*dexios-bia*) to receive D. whitei (=C. ovatus + C. parvirostris, which he identified as the right and left valves respectively of the same shell) and another and quite different form, D. halli, which is possibly identical with Prof. Hall's C: rhomboidea. The diagnosis of the genus is as follows: "Shell thin, inequivalve, inequilateral; beaks separated by an undefined area. Right valve very ventricose, with a prominent umbo, and a produced, incurved beak, strongly inclined forward. Left valve much less inflated, with a less prominent beak, scarcely elevated above the dorsal margin. Hinge-line more or less extended, straight, or slightly bent, edentulous (?) furnished with a thickened cartilage plate bearing a linear posterior groove. Pallial line and muscular marking unknown."

The two species associated in this genus differ so greatly that it may be seriously doubted if they can continue in the same genus.

Unfortunately for the comparison, the right valve alone of D. halli appears to have been found, thus leaving open the question as to its being inequivalve. The hinge-line is straight and produced in this species, while it is quite inconspicuous and curved in D. whitei. The greater number of characters of Dexiobia, however, apply better to the second species, though in that case the name, as it proves, is less applicable, some at least, of the species being nearly equivalve.

In this predicament the best that can be done seems to be to regard "C. ovata" as the type of the genus Dexiobia with somewhat limited characters, even though strongly suspicious that that species properly belongs under Cardiopsis. The remaining forms from the Waverly must then constitute a new genus.

A considerable suite of specimens, all from the upper part of the freestone enables us to prepare the following description.

Shell of medium size, obliquely ovate in outline, quite convex, asymetrical. Right valve generally somewhat higher than long, variable, triangularly ovate, very gibbous; anterior margin evenly rounded; lower margin gently curved or somewhat straight; posterior margin more acutely rounded, passing obliquely into the short hinge-line which bears the impress externally of two teeth, one being anterior the other posterior; beak very prominent, acute, extending above and arching over that of the opposite valve; greatest convexity about at the middle of the surface which falls off rapidly in all directions; surface ornamented by nearly sixty rounded costæ and irregular concentric striæ and folds. Left valve obliquely ovate, produced posteriorly, slightly convex, with a short, obtuse beak; post-umbonal plane at right angles to the valve; surface marked as in the other valve. The valves meet closely. Greatest height 20 mm, length 18 to 20 mm. About 16 costæ to a centimeter in a specimen 20 mm. high; in smaller specimens twice as many.

It is indeed possible that two species are represented by our specimens. The greater number resemble Cardiopsis radiata in the surface markings but are certainly inequivalve and resemble D. ovata in outline more nearly than Cardiopsis. If Cardiopsis should be found to be inequivalve it would relieve us of the necessity for the additional generic term. The fact that the two forms are derived from the same horizon is suggestive.

GENUS ORACARDIA. Gen. n.

Dexiobia, WINCHELL (pars. ?) (*Ety.* oraios-kardia.) Type A. ornata.

Shell somewhat inequilateral, more or less inequivalve, both valves quite ventrcose, with a strongly curved, acute, elevated beak, which inclines forward at the apex. Hinge-line extended, produced posteriorly, furnished with a thickened ridge or cartilage plate. The beaks are separated from the hinge by a pseudo-area which is elevated and more or less arched under the beak.

Surface marked by radiating lines which do not tend to increase in number toward the front.

ORACARDIA ORNATA, sp. n.

(Plate IV, Fig. 8, 9, 10.)

Cf. *Dexiobia halli*, WIN.

With the characters of the genus. Shell transversely semi-elliptical, somewhat oblique, hinge-line as long as the shell, straight; beak acute, oblique, recurved, elevated; anterior slope concave, flattened, producing a double ridge, posterior slope more regular, convex or flattened; greatest convexity at about one-third the height from the beak, front portions curving very abrubtly to the broadly curved lower margins; anterior margin meeting the hinge by a gentle curve. Surface marked by rounded distinct ribs which are closely set and continue for the most part from beak to lower margin, also by irregular concentric folds.

The area is acute below the beak. Judging from our specimens the right valve is somewhat more convex than the left but not remarkably so. Height of a left valve, 22 mm., length, 27 mm., convexity 9 mm., six striæ occupy a distance of 5 mm., at the lower margin. Several specimens were found near the top of the freestone of middle Waverly. A very small specimen apparently of this species was obtained 108 feet above conglomerate I in Richland Co. Dexiobia halli, and Cardiomorpha rhomboidea may both refer to this species, though the description of the latter is insufficient and the former is said to be smooth.

ORACARDIA CORNUTA, sp. n.

(Plate IV, Fig. 6.)

Shell small, body subquadrate or semi-oval. Right valve (alone known) with the body nearly quadrangular but enormously produced at the umbo, to form the very high, strongly coiled beak which extends half the height of shell above the hinge, which is straight, equalling the greatest length and bears the impress of the usual cartilage plate or ridge. The surface of the cast bears traces of numerous radiating and concentric striæ. The shell might at first be taken for a Platyceras if the hinge were overlooked. Height, 11 mm., length. 9 mm.

Immediately below congl. I with Palæoneilo elliptica,

CONOCARDIUM ALTERNISTRIATUM, sp. n.

(Plate XI, Fig. 24; Plate V, Fig. 7. ?)

Of medium or large size for the genus, rather strongly convex. Lateral surface composed of two facets or curved, triangular planes separated by a more or less well-marked depression or groove, of these the anterior is strongly convex to the incurved beak, is about twice as wide as high and marked by about ten distant ribs which are separated by intervals wider than the ribs, both the depressions and the tops of the ribs being plane; the posterior portion of the surface is less convex and longer than high and is marked by over twenty closely set and very irregular ribs, there is a tendency to alternation but frequently two or three of the smaller costæ separate those of the larger set; the ant-umbonal surface is heart-shaped in outline and rather strongly concave to near the projecting tubular projection, where it is strongly reflexed, marked by 12–14 rather closely set arching ribs. Surface finely marked by concentric striæ especially between the ribs.

All the specimens of this fine species seen were more or less distorted as is usual in this genus, hence it is not safe to rely too implicitly on proportions as seen in any specimens.

Height of small specimen, 15 mm., length from umbonal ridge to posterior, about 16–18 mm., convexity of both valves, about 10 mm. Height of a larger specimen along umbonal ridge, 24 mm.

Bagdad and Burbank, Ohio, above the concretionary shales of Lodi.

There is no species known to us sufficiently resembling this one to require comparison.

Genus Palæoneilo.

Much yet remains to be done in the way of comparative study of these perplexing forms of which our material is far from satisfactory. We are inclined to withdraw the name *Goniodon*, provisionally used for some of these forms, though G. ohioense can hardly enter any of the genera as now limited. The hinge, however, probably had true teeth in an uninterrupted series. Our series begins in the Bedford shales in northern and central Ohio, with a species of Palæoneilo, called by Meek, P. bedfordensis, but which is very closely allied to Hamilton P. constricta. Something over one hundred feet higher we find our P. consimilis which somewhat resembles in outline P. maxima of the Hamilton.

PALÆONEILO CONSIMILIS, sp. n.

(Plate IV, Fig. 14.)

Very similar to P. bedfordensis, but more elongate. Sub-ovate, produced posteriorly; length to height as 17 to 12; basal margin very convex opposite the beaks, curving regularly toward the front but straightened, almost sinuous, toward the narrowed posterior extremity; hinge declining from the beaks, which are near the anterior third; surface rather flat with an obscure sinus posteriorly, marked by very fine concentric striæ. Length, 17 mm., height, 11 mm. This species connects P. bedfordensis with P. ignota and does not greatly differ from the extremely elongated varieties of P. constricta.

When describing P. bedfordensis Mr. Meek refers to P. brevis of the Chemung as its nearest ally. Had he, however, compared it with P. constricta he might have hesitated to distinguish it. Compare, for example, our Fig. 8, Plate IX, with Fig. 3, Plate XLVIII, Vol. V, Pal. N. Y. The only difference appears to be the bolder sweep of the anterior outline in P. bedfordensis.

Near Harlam, Delaware Co., O.

PALÆONEILO IGNOTA, sp. n.

(Plate IV, Fig. 15.)

Shell of medium size, moderately convex, rather thick, height two-thirds the length, the greatest height a little posterior to the beaks which are one-third the distance from the front, basal margin semi-elliptical, terminating before and behind at nearly one-half the height; anterior margin sub-parabolic; posterior outline rather acutely terminating at about one-third the height from the somewhat oblique hinge; posterior projection compressed; surface most ventricose near the middle, marked only by very fine, numerous, crowded concentric striæ. Hinge with five moderate teeth in front and fifteen or more very fine denticules behind which diminish toward the beak.

The shell could easily be mistaken for a Nucula (Ctenodonta) as frequently used but is obviously related to the group of Palæoneilo, found in the Chemung. Length, 14 mm., height, 9 mm.

Moderately abundant in Nodules at Moot's run, Licking Co.

This species bears some resemblance to P. bedfordensis, Meek, but is not sinuous or greatly compressed posteriorly.

PALÆONEILO (NUCULA ?) CURTA, sp. n.

(Plate IV, Fig. 4.)

Quadrangularly sub-oval, moderately convex, hinge and front margins sub-parallel; posterior margin evenly rounded, anterior margin acutely angled, lunule strong; beak one-fourth from the front; hinge in front of the beak with five or six small teeth, behind with seven stronger denticles. Length, 11 mm., height, 6.5 mm. Freestone of middle Waverly.

PALÆONEILO SULCATINA, Win.

(Plate IV, Fig. 17.)

Quite common forty feet below conglomerate I, Union, Licking county.

NUCULA (CTENODONTA) HOUGHTONI, Stev.

(Plate IV, Fig. 3; Plate X, Figs. 4, ?.)

This species in several minor varieties seems to extend from the

middle to well into the upper third of the Waverly. The figures on plate four represent specimens from a horizon forty feet below conglomerate I, that on Plate X, from Cuyahoga Falls.

NUCULANA, sp.

(Plate IV, Fig. 12.)

A small species known only from imperfect casts differs from all other Waverly species in the outline. The anterior portion is very short and abrubtly rounded. The hinge margin is straight and oblique to the axis of the shell. Posterior portion short and acute; surface moderately convex. Length, 9 mm., height, 5 mm., beak about 2 mm. from front.

Williams quarry, Granville. Freestone.

NUCULANA NUCULÆFORMIS, Stevens?

(Plate IV, Fig. 23.)

Opportunity has not presented for careful comparison with authentic specimens of this species hence our identification is provisional. Found associated with Ctenodonta houghtoni above conglomerate II at Newark. Length, 18 mm., height, 10 mm.

NUCULANA, sp.

(Plate IV, Fig. 11.)

This is the characteristic species of this genus in the freestone, but the material is too imperfectly preserved for description.

FLEMINGIA (?) STULTUS, sp. n.

(Plate VII, Fig. 10.)

Shell small, acutely conical; spire composed of five whorls, obliquely flattened along the dorsum to produce a plane conical spire with sub-carinate suture; surface of cast unmarked. Diameter of lower whorl, 10 mm., height of spire, 11 mm. The body whorl is strongly angulate along the free side and slopes rapidly to the umbilicus which with the aperture is unknown. A single specimen from

the freestone of the middle Waverly is thus named because of the conical spire resembling a fool's cap.

Since writing the above a number of specimens imbeded in the freestone near the top of division II have been collected. These specimens seem to prove that our species is a trochoid shell and not a Pleurotomaria. No evidence of a peripheral revolving band or of a notched outer lip can be observed, while the strictly conical spire and angulated lower margin of the body whorl and what can be seen of the lip suggest *Flemingia*. The spire is often higher than in the specimen drawn and the outer surface of the volutions somewhat convex, but never in either respect equalling Flemingia turbinato-conica of Dekoninck. It may be compared with F. coniformis, Dek. There are usually four whorls which are marked in the casts only by the impressed lines of growth. The aperture is not well preserved but seems to be lenticular. The umbilical surface of the lower whorl forms nearly a right angle with the spire.

Height of spire in largest specimen, 13 mm., diameter of largest volution, about 12 mm. Other specimens are only 4 mm. high, and equally broad.

PLEUROTOMRIA TEXTILIGERA, Meek.

(Pal. O., Vol. II, p. 314.)

This pretty species is quite common at Bagdad, and occurs also at Lodi on a slightly lower horizon. It has not been found in the central or southern part of the state.

PLATYCERAS LODIENSE, Meek.

(Plate XI. Fig. 2; Plate VIII, Figs. 1 and 7.)

We have specimens from Bagdad which may represent this species if Meek's description was prepared from a young or imperfect specimen. Much variation is permitted within species of this genus. The following added particulars are noted:

The shell though never spirally coiled may be considerably arched and restricted at the tip or it may be nearly straight above the posterior margin of the aperature. The carina of the anterior surface (in the cast) does not reach the aperture in large specimens but terminates by a triangular attenuation. Near the aperture the sides are

more or less plicate. The apex of our specimens resembles Meek's figures.

ORTHOCERAS HETEROCINCTUM, Win.?

The specimens referred to this species are all fragments and are insufficient to fully determine the identity.

Shell unequally annulated, tapering rather rapidly, section subcircular, siphuncle central (?). Chamber of habitation very long, annulated irregularly, annuli rounded, separated by shallow concave grooves. Septa slightly oblique, distant about one-fourth the diameter or less; septate portion very irregularly or scarcely annulated; surface marked by close, concentric, raised striæ. Transverse diameter, 12 mm., chamber of habitation, 38 mm., distance of septa, 3 mm.

Lodi and Burbank, Ohio.

GYROCERAS, sp.

A species apparently of this genus with close resemblance to G. Rockfordensis, M. & W. is found in the upper division, perhaps seventy feet above conglomerate II. It seems rather larger than the species quoted, but in general characters, so far as known, is similar.

CONULARIA VICTA, White.?

(Plate VIII, Fig. 3.)

WHITE, Proc. Bost. Soc. N. H, vol. IX, p. 22.

Shell square-pyramidal, moderately acute, uninclined, with the sides nearly equal, and moderately convex, inclined to each other by about 15 degrees. The angles are marked by the usual grooves, into which the striæ pass without abrupt downward flexture, meeting nearly directly, while the middle of the lateral faces bears an ill-defined suture (which is rather the intersection of two synclinal planes of the surface than a groove) where the striæ meet at rather large angle and generally in opposition rather than alternately. The inclination of the striæ is such that at the median groove the striæ are nearer the aperture by the width of from five to seven striæ than at the angles. The surface is marked by very numerous, acutely ridged striæ, of which there are 28 to the centimeter or 70 to the inch, these striæ were sharply ridged or keeled but apparently not crenulated, groove separ-

ating the striæ narrow, rather shallow, unornamented. Length of specimen 45 mm., width near the base about 14 mm.

From C. micronema, which it most resembles, this species differs in the greater coarseness of the striæ which are hardly half as numerous, and especially by their sharp curvature toward the aperture thus intersecting more acutely at the median groove.

The species may be compared with C. sub-carbonaria of the Keokuk group but obviously differs in several characters. Unfortunately our specimens do not preserve the surface sufficiently to make the absence of sculpture certain, while the figure has been restored as to the aperture and must not be too fully trusted in that respect. Other specimens differ from that figured in the less acute intersection of the striæ at the median suture and seem to have a minute pearling of the summits. The number of striæ varies from 45 to 70 in one inch.

Associated with C. newberryi, in the upper division from 50 to 100 feet above conglomerate II, Newark, Rushville, and near Loudonville.

CONULARIA GRACILIS, sp. n.

(Plate VIII, Fig 2, also Plate VI, Fig. 13, vol. iii.)

In our discussion of C. newberryi in the last volume the differences existing between the Conularias of various horizons were referred to, especially in the case of the form found at Moot's run and elsewhere, at a distance of seventy feet below conglomerate I. This form is now represented by abundant material and proves to be a very distinct and remarkable species. C. newberryi itself seems only to occur above conglomerate I, being abundant in shales just below conglomerate II and in division III. It is found in the Cuyahoga shales and seems to attain the coal-measures. The present species may be defined as follows:

Shell quadrangular, extremely elongate with nearly parallel sides, attaining a length of five inches or more. In a specimen 18 mm. wide at the base there are eight ridges in one centimeter but they vary with their position and size of the specimen. Lateral surfaces flat with but a faint median suture, while those of the angles are well defined. The summits of the ridges are ornamented by closely set bars parallel to the length of the shell which are strictly limited to a zone bordered by a depression on either side. The ridges arch gently. Mouth with well developed lips. (See Plate VI, Vol. iii.)

Moot's run, and near Loudonville, 60 to 80 feet below conglomerate I, also at Alexandria, O.

CONULARIA MICRONEMA, Meek. var. n.

(Plate VIII, Fig. 4.)

Shell square-pyramidal, moderately acute, uninclined, with the sides nearly equal, nearly plane or gently convex, inclined to each other at an angle of about fifteen to eighteen degrees. The angles are marked by the usual groove into which the striæ pass by a very sudden flexture, while the middle of the lateral faces bears a definite though narrow groove, across which the striæ do not pass. The surface is marked by very numerous, closely crowded, thread-like, gently curved striæ of which there are 60 to the centimeter or about 150 to the inch; these striæ are ornamented by pyramidal prominences which are separated by a distance less than the interval between consecutive striæ.

CRUSTACEA.

Considerable attention has of late been paid to the trilobites of the Carboniferous and immediately preceeding formations.

Beginning with a brief synopsis by the writer in May, 1887,* and a description of a perfect specimen of *Phillipsia auriculata*, there followed in the same year Lieut. Vogdes' "Genera and species of N. A. Carboniferous Trilobites," and in the next year, in April, a description of *Phillipsia* (*Proetus*) *Præcursor* in Bul. Den. Univ. vol. iii, and a little later the last volume of the Palæontology of New York in which are discussed a large number of Devonian and Carboniferous species.

One or two points in Mr. Vogdes' valuable paper should be noted. For example, on page 81, in quoting *Phillipsia trinucleata*, Herrick, he refers to it as from the Waverly instead of a well-authenticated coal-measure horizon. Influenced apparently by this impression the

*"Synopsis of Carboniferous Trilobites" forming appendix I to the first installment of the present article entitled "Carboniferous Fossils, from Flint Ridge, Ohio." This paper has been quoted by continental reviewers as by Mr. Flint Ridge, Esq., illustrating at once the illusory character of fame and the care bestowed by trans-atlantic authors in dealing with American papers.

species is referred to the genus *Proetus* to which it can hardly be assigned upon any of the various definitions of that genus.

The case of *Proetus missouriensis*, Shum. is likewise somewhat confused. *Proetus auriculatus*, H. is said to extend from the Chemung into the Waverly group, while as a matter of fact it was originally described from Granville, O., where our author states P. missouriensis is found. Though originally referred to the Chemung these strata are typical Waverly. Prof. Hall, moreover, identifies his species with *P. missouriensis*. Nevertheless Mr. Vogdes states that in specimens from Cameron, Missouri the "genal angles *appear to be* obtusely rounded off," and they are so drawn. Certainly the head figured on Plate III, of that paper differs widely from that drawn by Meek, which is copied for comparison, and is totally unlike the Ohio specimens in the character of the movable cheeks.

Prof. Hall in his last report insists that this species is a Proetus though recognizing the specific identity of Missouri and Ohio specimens. The question is largely one of individual opinion as to the limits of the two genera. Though the writer would prefer to restrict the application of the name Proetus to species of the group of *P. bohemicus*, Corda, reserving those with large basal lobes and but two distinct furrows upon the glabella and longer head-shield for the genus Phillipsia, the question must be decided by the consensus of palæontologists.

The catalogue of Mr. Vogdes as thus corrected includes from the Waverly the following five species of Proetus: *P. auriculatus*, *P. loganensis*, *P. peroccidens*, *P. ? ellipticus* and *P. tennessensis*, but it is still uncertain how far the Wahsatch strata referred to the Waverly are really equivalent to the original Ohio formation, thus two of these are rendered doubtful, viz: P. loganensis and P. peroccidens. To these must be added four species referred to Phillipsia, P. doris, P. insignis, P. meramacensis and P. rockfordensis of which some may prove to belong to Proetus.

The list is then completed with *Brachymetopus* (?) *lodiensis* making ten species from the Waverly and its equivalents. To these we shall add seven additional species, all from the Waverly in Ohio and this by no means exhausts the known species, for several forms are too imperfectly represented for intelligible description. It must be noticed at the outset that the Waverly is not a homogeneous formation but a convenient term for a series of strata in Ohio which are more or less

similar lithologically, though including representatives of all the epochs from the Hamilton to the Chester or St. Louis. The evidence upon this question will be given at length in the sequel. Using the provisional divisions of the Waverly as suggested in our earlier discussion of this group we find the distribution of species in Ohio as follows; Upper division (carboniferous), *Phillipsia meramacensis*, *P. serraticaudata*, sp. n., *Phillipsia*, sp. n. (closely related with *P. auriculatus*,) *Phaethonides occidentalis*, sp. n., and *Phaethonides immaturus*, sp. n.

In division II, or that consisting of the freestone of central Ohio and the adjacent shales, we have thus far but the single species, *Phillipsia auriculata* (=Proetus missouriensis) while in division I, embracing the lower and larger portion, we find *Phaethonides spinosus* sp. n., *Phillipsia* (?) *consors*, sp. n., *P. lodiensis*, Meek? *Proetus præcursor*, Herrick, *Proetus minutus*, sp. n., and *Proetus* sp. ?, as well as near the top *P. auriculatus*. Thus in the lowest member the genera Proetus and Phaethonides predominate and the species referred to Phillipsia are at least closely related to Proetus and are of a Devonian rather than a carboniferous aspect. The middle division introduces no new element while the upper contains true Phillipsias as well as species of *Phaethonides* nearly allied to the carboniferous genus Brachymetopus. So far then as the distribution of the trilobites is concerned all facts sustain the conclusions elsewhere expressed as to the Devonian affinities of the faunæ of the two lower members. We add descriptions of the species.

Genera Phillipsia and Proetus.

While extreme examples of these genera as now understood are readily distinguished, they merge imperceptibly into each other, making the task of separating the allied forms very difficult. If one relies solely on the number of thoracic segments the resulting assemblages will be otherwise inconsistent not to mention the practical difficulty that, as the complete thorax is rarely preserved, we are forced in practice to depend on characters of pygidium and head. If it could be agreed to limit the genus Proetus to forms like P. bohemicus, Corda, the problem would be more simple. We append the diagnoses of the genera in parallel columns.

PHILLIPSIA.	PROETUS.
General form oval.	Do.
Head never over one-third the length and shorter than pygidium.	Head shorter than one-third and shorter than pygidium.
Head surrounded by raised border.	Do.
Glabella with parallel sides.	Do.
Basal lobes separated by a distinct furrow from rest of glabella.	Do. but smaller and more transverse.
Glabella with two or three furrows.	Glabella with three more or less distinct furrows.
Free cheeks produced into spines.	Free cheeks triangular less, frequently with spines.
Cervical suture deep, cervical segment high.	Do.
Eye large, facetted.	Do.
Thoracic segments nine (or ten.)	Thoracic segments eight to ten.
Pygidium with a rounded border which is usually narrow.	Border of pygidium rather broad and flat.
Number of segments large (from 10–18.)	Number of segments less (4–13).

PHILLIPSIA SERRATICAUDATA, sp. n.

(Plate I, Fig. 8, a—d.)

Glabella a little longer than wide, apparently about one-third as wide as entire shield, moderately elevated, surface rather depressed, narrower anteriorly, marked by three distinct lateral sulci with some indications of a fourth; postero-lateral (basal) lobes rather small, very oblique; produced back of the median lobe; the second and third furrows short, near together but separated by a wider interval from the first and less oblique. The elevated median lobe is separated by the very narrow anterior border by a narrow deep sulcus; neck segment very broad. Only a part of the movable cheek has been seen and it cannot be determined whether it is mucronate or not.

Outline of pygidium parabolic, length about two-thirds the width; median lobe rather convex, composed of about twelve segments which are separated by rather deep rounded grooves; lateral lobes moderate-

ly convex, marked by the same number of annuli as the median one, which are continuous to the very narrowed abrupt border. Segments ornamented along the posterior margin of the elevated portion by short, sharp, curved spines. This species is remarkable also for the distance of the convex, rather prominent termination of the median lobe from the free margin.

Length of glabella, 10 mm., width, 7.5 mm., distance from third lateral furrow to front 4.5 mm. Length of pygidium, 9 mm., width, 10 to 11 mm.

Seventy-five to one hundred feet above congl. II, Newark, 100 feet above congl. II, Rushville, and 108 feet above congl. II, in Richland Co. The horizon from which this species comes is well marked and restricted.

PHILLIPSIA (?) CONSORS, sp. n.

(Plate I, Fig. 16, a, b, c.)

Closely related apparently with P. serraticaudata, Her. Glabella almost exactly as in that species, length to width, as 8.5 to 5.5 at basal lobes; narrowed in front, depressed, marked by three lateral grooves, surface very densely marked by pustules of two sizes. From the species quoted the glabella differs in being rather longer proportionally, and more densely marked. The anterior part of head was not seen but very likely the border is narrow. Pygidium strongly elevated, parabolic, with a very narrow, smooth border; median lobe reaching rather nearer the posterior of pygidium than in P. serraticaudatus, composed of from 9 to 12 segments which are narrow, separated by concave grooves and ornamented by numerous perpendicular (not curved) pustules; lateral lobes strongly curved with about nine obvious segments ornamented as above.

Length of median lobe of glabella, 8.5 mm., width, 5.5 mm., length of pygidium, 9 mm., width, 10 mm. When flattened the pygidium approaches in proportions those of P. serraticaudata.

Five specimens were obtained at Lodi while looking for P. lodiensis, but there can be no possibility of our specimens belonging to that form. The structure of the head a little suggests P. præcursor, above the horizon of which it lies.

PHILLIPSIA MERAMACENSIS, Shumard.

(Plate I, Fig. 6.)

Our knowledge of this species rests on the single pygidium from an isolated exposure on a horizon about seventy feet below the Chester and apparently 110 to 120 feet above congl. II. It is undoubtedly near the horizon of P. serraticaudata. In as much as P. meramacensis was described from strata referred to the Chester, the close stratigraphical relation to acknowledged Chester rocks in Ohio is suggestive of an inference suggested by other facts, i. e., that the supposed hiatus above the Waverly does not in reality exist or at least is not as great as supposed. The Chester at this place is but about twenty-five feet thick and is followed without unconformity by sandy shales and a micaceous sandstone introducing the coal-measures. For description see Bul. Den. Univ vol. iii, p. 28, and Plate XI of the same volume but published with Vol. IV.

PHILLIPSIA (PROETUS) AURICULATUS, Hall

(Plate I, Fig. 14.)

Proetus missouriensis, SHUMARD.
Phillipsia shumardi, HERRICK.

For as complete a description as now possible see Bul. Den. Univ. vol. ii, p. 69.

The range of this species is for the most part limited to the freestone of middle Waverly, but a specimen has been found immediately below conglomerate I and a variety not at present specifically separable occurs up to one hundred feet above conglomerate II. See opening sentences of present article for history of the species.

PHILLIPSIA (PROETUS) PRÆCURSOR, Herrick.

(Plate I, Fig. 1.)

This is a beautiful and characteristic species and seems quite rigorously limited to a zone scarcely 30 feet thick about seventy-five feet below conglomerate I. Specimens have been found only in one locality four miles west of Granville, where, however, the species is abundant.

Our P. præcursor differs from P. haldemani in having the genal angles produced. It is much like P. microcephalus but has a shorter glabella and smaller basal lobes.

In connection with this genus it is necessary to notice the only exception to the statement that no species of Phillipsia is known below the Waverly. *P. longicaudata*, H. described as from the Hamilton though some doubt was expressed whether it was not after all a coal-measure species, is certainly a Phillipsia and, judging from the figure, identical even in the state of preservation with *P. sangamonensis*, M. and W. It seems quite likely that the same specimen was employed in both figures, though it was derived from an unknown locality north-east of Des Moines, Iowa.

The genus Phillipsia proper, begins at the beginning of Division III, i. e., at that horizon which most nearly corresponds with the lower part of the Burlington group, and forms the introductory member of the Carboniferous in Ohio.

Genus Proetus.

The Devonian of America is well supplied with species of this genus, of which five species are found in the upper Helderberg. The corniferous limestone contains *P. folliceps*, *P. clarus*, *P. canaliculatus*, *P. verneuili*, *P. microgemma*, *P.* (?) *planimarginatus*, *P. stenopyge*, *P. ovifrons*, *P. delphinulus and P. tumidus*—ten species. In the Hamilton Prof. Hall notes, *P. haldemani*, *P. macrocephalus*, *P. rowi*, *P. jejunus*, *P. phocion*, *P. prouti*, *P nevadæ*. *P occidens*.

Then, strangely enough, the race seems to end So far as evidence thus far has offered, trilobites ceased to exist with the end of the Hamilton, as no remains are known from the Portage and Chemung strata. This has naturally given much trouble to geologists in view of the considerable development of these crustacea in the Carboniferous. The whole difficutty disappears when the view here advocated is accepted and we find in Ohio a continuous sequence from Hamilton to Coal-measures with no serious break. The Hamilton genera are very gradually superceeded in the lower Waverly and the transition to the coal-measure species is complete.

PROETUS (?) (cf HALDEMANI, H.)

(Plate I, Fig. 12)

Our material is too poor to permit a rigid definition of the species, but its position is so near the base of the Waverly that its peculiarities may warrant a reference.

Head unknown; thorax consisting of nine slightly convex segments, the axial and pleural portion having about the the same width, length slightly over twice the width; pygidium over one-half as long as broad, very flat, consisting of about ten coalesced segments, axial lobe very wide, considerably over one-third the entire width, terminating obtusely near the margin; pleural surface gently convex with about nine obvious segments which are low and separated by shallow grooves. There are some indications that there may have been a broad plane border, in which case the proportions would correspond to P. shumardi quite nearly. It is quite unlikely that it is identical with that species, however.

One mile east of Harlam, Licking Co., in shale 200–300 feet from the base of the Waverly.

PROETUS MINUTUS, sp. n.

(Plate I, Fig. 7, a, b.)

An exceedingly small species quite unlike its associates.

General form broadly oval, head as long as the pygidium; glabella large with very small, strongly marked basal lobes and elevated median lobe, which is narrow, with parallel sides and terminates at some distance from the front margin. The markings are not displayed, the surface being exfoliated. Cervical suture deep, cervical segment apparently narrow. Median lobe of glabella nearly twice as long as broad. Thorax with nine segments, very distinctly trilobed. Pygidium two-thirds as long as broad, with a very wide concave border, axial segments eleven or twelve, pleural segments eleven. Pygidium rather flat with rounded costæ which disappear toward the margin.

Moot's run, Licking Co., O.

Genus Phaethonides, Angelin, 1878.

The present writer had gone so far as to separate the species now to be described with Phillipsia lodiensis, Meek, as constituting a separate genus allied to Brachymetopus when the adoption and modification by Prof. Hall of the genus Phaethonides fell under his notice. Hall, however, does not entirely agree with its founder in the application of the name to the group for which Barrande proposed Phaethon.

This name was applied to proetoid forms with fimbricated pygidium. As amended by Angelm, this genus includes both forms of pygidia where the glabella is short and ovoid, having distinct basal lobes and two pairs of faint obsolescent, lateral furrows in front of the lobes. As stated by Hall the genus connects Cyphaspis and Proetus and (as he might have said) introduces Brachymetopus.

Diagnosis. Cephalon as in Cyphaspis [semicircular, genal angles produced into spines. Glabella strongly arched, short and narrow, with two small pyriform basal lobes, bounded on all sides by deeply impressed furrows. Anterior lateral furrows obsolete] the frontal area, however, being more deeply concave and the lateral glabellar furrows stronger and generally duplicate. Thorax composed of not less than seven narrow segments and probably more. Axis wide. Pygidium Proetoid, relatively large, bearing from eight to twelve annulations upon the axis and eight or nine upon the pluræ. These annulations extend to the margin and are conspicuously duplicate their entire length. Surface turbercled or smooth." The genus extends from the Upper Helderberg to the Hamilton, and, as we now show, to the close of the Chemung in Ohio.*

PHAETHONIDES OCCIDENTALIS, sp. n.

(Plate I, Fig. 10, a, b.)

Glabella two-thirds as long as the head-shield not including the neck segment, sub-oval, quite tumid behind but flattened anteriorly, highest point rather behind the middle, distinctly separated by a groove from the small lateral lobes, also marked near the anterior third by a slight depression at the sides; head-shield in front of the glabella gradually descending to the rather narrow somewhat elevated border which is set off by a broad ill-defined groove; eyes apparently distant from the glabella, cervical segment narrow, separated from the glabella by a narrow deep groove, entire surface tuberculate. (The specimen does not preserve the entire shield, but it was evidently much more broadly rounded than is usual in Brachymetopus.)

Pygidium semi-elliptical, elevated, consisting of about sixteen

*In the Trans. of N. Y. Acad. Sci., June 4th 1888, Mr. Vogdes describes from the Waverly of Sedalia, Mo., *Griffithides ? sedaliensis*, Vogd., which seems to belong to the present group.

united segments, axis rather more than one-third the entire proximal width, tapering gradually to its blunt prominent distal extremity, which is near the margin, strongly elevated and ornamented by a series of tubercles on each of the segments, which are circular in section and separated by deep, narrow grooves; pleural portions suddenly and strongly deflected at a short distance from the axial lobe, but becoming less oblique to form the narrow margins which are not otherwise defined, the nine or ten pleural ribs are elevated and keeled, the keel bearing from two to five small tubercles and extending out upon the free margin as a strong rib, terminating in a tooth or tubercle on the free margin; length of pygidium four-fifths or more of the width. Length of pygidium, 8 mm., width, 10 mm. Length of head-shield, 7 mm., length of glabella, 4.4 mm.

Several heads and pygidia were collected in conglomerate II at Granville and Newark.

PHAETHONIDES SPINOSUS, sp. n.

(Plate I, Figs. 4–5.)

Glabella two-thirds as long as head including the neck-segment, narrow, not much expanded posteriorly, form much as in P. occidentalis, but with smaller postero-lateral lobes and no indication of an anterior pair of grooves. Anterior margin of head narrow, separated from the median lobe of glabella by a very shallow concavity which becomes convex as it nears the glabella. Surface profusely set with high tubercles, those upon the glabella forming about eight rows, lateral lobes with three small spines.

Pygidium of large size for the genus, very convex and much arched, composed of fourteen coalesced segments, axial lobe elevated, its segments moderately convex, separated by comparatively shallow and not very narrow grooves, and ornamented by five sharp almost spinous tubercles, of which the central one is largest and separated from the lateral ones by a greater interval than separates the latter; pleural surfaces convex, suddenly depressed near the middle of their width nearly perpendicularly to the shallow groove separating the very narrow margin; eight or nine pleural ribs carinate, with from one to four spinous tubercles, ribs nearly disappearing in the marginal groove but springing into an oblique acute spine on the raised margin. The ribs of the pleura bifurcate near the margin by the division of that por-

tion of the ribs behind the keel. Length of head, 6 mm., length of glabella, 4 mm., width, 3 mm. Length of pygidium, 7 mm., width, 9–10 mm.

This beautiful species is found at Moot's run 70 to 80 feet below congl. I. The pygidium is very like that of P. occidentalis but the greater coarseness of the ribs and the spinous armature with minor features serve to distinguish the species, which differ more widely in the characters of the head.

Calcareous concretions seventy feet below conglomerate I, Licking and Ashland counties.

PHAETHONIDES? IMMATURUS, sp. n.

(Plate I, Figs. 9 and 15.)

This species is known only from pygidia, none of which preserve the characters perfectly. It is quite possibly this is the species described by Meek as Phillipsia lodiensis but in as much as it is not found on the same horizon it seems better to distinguish it.

Pygidium rather flat in all specimens seen, semi-elliptical, axial portion with about twelve lobes, rather rapidly tapering, pleura with duplicate ribs anteriorly, about eight being visible, extending out upon the rather narrow but obvious margin where they are slightly nodose, median and lateral lobes ornamented by about three large distant tubercles. This is a very small species occurring 100 feet above conglomerate II, at Newark and also in the upper layers at Cuyahoga Falls. Fig. 9 is from the latter place and considerably enlarged by camera. It has been called P. lodiensis by collectors.

PHAETHONIDES (?) LODIENSIS, Meek.

(Geol. Surv. O. vol. ii. Palaeon. Plate XVIII.)

The figures of this species make it probable that it is congeneric with P. spinosus and it is apparently but little above it stratigraphically. Collectors seem to have confused with it our P. immaturus or other species from a higher horizon. The form of glabella with the long median lobe ally it with some forms of Proetus.

CYTHERE OHIOENSIS, sp. n.

(Plate VIII, Fig. 8, Vol. III. Plate III, Fig. 19.)

Carapace narrowly ovate, smooth; profile rhomboidal, acute at either end; valves marked by a rather acute prominence near the middle of the length and one-third from the dorsal margin, surface very strongly arched toward the dorsal margin, more gently inclined to the ventral margin.

Length, 7 mm., width, 35 mm. Common in the upper part of division III, at Newark, Rushville and Ashland Co.

The generic reference is purely provisional, the species resembles a Leperditia in some respects, though seeming like an enlarged Cytherella. It may be compared with a form figured by Meek from Nebraska.

Before taking up the general discussion of the list here presented we should study the Cœlenterata, Echinodermata, Bryozoa, and Pisces, of all which groups more or fewer specimens have been secured. Unfortunately the material collected in all but one is very meager, while the crinoids have already been quite fully discussed by Prof. Hall. The Bryozoa are abundant upon several horizons. We have been so fortunate as to secure the assistance in this difficult group of the highest authority upon the subject of sub-carboniferous Bryozoa, Mr. E. O. Ulrich, whose work in connection with the Geological surveys of Minnesota and Illinois places him in a position to speak authoritatively upon this group. This is of special moment in the present instance in as much as the localities furnishing Bryozoa (excepting a single horizon) are well up in the series and have been referred on other grounds by us to just those epochs chiefly represented in Illinois,

Of the kindness of Mr. Ulrich in preparing and donating the following paper we desire to make special acknowledgment.

Prof. C. L. Herrick, Denison University, Granville, Ohio.

DEAR SIR :—

I transmit herewith a brief report on Waverly bryozoa. Had I been less pressed for time it would without doubt have been more full and more reliable. Still, I hope you will find it suited to your purpose.

By combining the fine lot of material you sent me for study with my own I believe I have been enabled to present a fair idea of the bryozoan fauna of this much-discussed series of strata. That which strikes one as not only interesting but important in the questions at issue relating to the equivalence of the various beds comprised within the term Waverly group is the fact that no remains of this class of fossils have as yet been obtained from strata below the top of the Berea shales. So far as I have been able to ascertain there is a complete absence of bryozoa in all the divisions between the top of the Erie and the base of the Cuyahoga shales.

In looking over the 41 species that have been determined, I find that no less than 17, or over 41 per cent. of the entire number, occur in the Burlington and Keokuk beds of Iowa, Illinois and Kentucky. Not a single species indicates an horizon above the base of the St. Louis limestone. Of these, 3 species occur in the Burlington and 16 in the Keokuk, while 2 of the Burlington species also occur in the Keokuk.

The bryozoa are thus decidedly indicative of an equivalence between the Cuyahoga shales on the one hand and the Keokuk group on the other.

Many of the species identified and others mentioned in drawing comparisons between nearly related forms are described in Vol. VIII, Illinois Geological Survey report. To prevent repetition the names of these species are usually distinguished by an asterisk.

Respectfully Yours,

E. O. ULRICH.

A LIST OF THE BRYOZOA OF THE WAVERLY GROUP IN OHIO. WITH DESCRIPTIONS OF NEW SPECIES.

By E. O. Ulrich.

FENESTELLA HERRICKANA, n. sp.

(Plate XIII, Fig 2—2d.)

Zoarium of moderate extent, apparently flabellate and more or less undulating.

Obverse:—Branches comparatively rigid and rather slender, eight or nine in 5 mm., 3.5 mm,, to 4.0 mm. wide, increasing very gradually to 4.5 or 5.0 mm. before bifurcation takes place; margins somewhat wavy; surface between the zooecia apertures depressed and marked with from one to three (usually two) short striations. *Carina* usually distinct but only moderately developed, not sharp, swelling or forming tubercles at intervals corresponding nearly to the zooecia mouths, occasionally nearly obsolete, in which case the nodes are more conspicuous than usual. Zooecia in two ranges, thirteen or fourteen in each in 5 mm., apertures four or five opposite a fenestrule, circular, 0.2 mm. in diameter, surrounded by well developed peristome which (in the perfect state) is ornamented by a circle of small tubercles. The space between succeeding orifices about equals the diameter of a peristome. Opercular coverings slightly convex, with a small central elevation. *Dissepiments* thin, depressed, faintly striated, rounded or sub-angular. *Fenestrules* narrow, the length two to four times greater than the width; seven or eight in 10 mm. longitudinally.

Reverse:—Here the branches are strongly rounded and striated longitudinally. On old example the striæ become nearly or quite obsolete and the whole surface finely granulose. The granules are of two sizes. the larger ones being much less abundant and inclined to arrange themselves in rows.

This beautiful species may be compared with the *F. cingulata** from the Keokuk group of Illinois, which likewise has a row of minute granules upon the peristomes of the zooecia. That species however, has a more compact and robust aspect, stronger dissepiments and shorter fenestrules. *F. compressa*,* from the same horizon in Kentucky has a much higher keel, and differs in other aspects.

Formation and locality:—Not uncommon at Moot's Run, Licking Co., O. Rare at Richfield, Ohio.

FENESTELLA MEEKANA, n. sp.

(Plate XIII, Fig. 1—1b.)

Zoarium of lax growth, probably flabellate, spreading nearly in a plane and, so far as known, not exceeding 50 mm. in height.

Obverse:—Branches rather strong and straight, seven or eight in 10 mm., with an average width of .05 mm., increasing from about 0.45 mm. immediately after bifurcation to about 0.60 mm., before the next division takes place. Bifurcation recurring at intervals, varying between 6.0 mm. and 11.0 mm. *Carina* obsolete; median region of branches with two to four rather unequal and irregularly flexuous striæ, and an occasional node. Spaces between zooecia apertures usually with two or three short striæ. *Zooecia* in two ranges, ten in each in 5 mm.; usually six or seven opposite each fenestrule, but, the length of the latter being variable, it sometimes happens that eight or even nine may be observed. *Apertures circular*, 0.12 mm., in diameter, separated two and one-half times that distance, with the margin thick and elevated but not ring-like. *Opercula* occasionally preserved, slightly convex and radially marked around the small central perforation or boss. *Dissepiments* striated, depressed, less than half the width of the branches, but expanding at their junction with them. *Fenestrules* large, varying from 0.7 to 1.2 mm. in width and 2.2 to 4.5 mm. in length, averaging, however, about three in 10 mm.

Reverse:—On this side the branches and dissepiments are rounded and marked by granulose striæ, four or more on each branch.

In Vol. II Pal. of Ohio, Meek describes from about the same horizon at Lodi, a form which he separates as a variety of *F. multi-*

*This mark appended to a species signifies that it is one of those described by me in theforthcoming Vol. VIII of the Reports of the Illinois Geological Survey.

porata, McCoy. After a careful study of his figures and description it seems evident to me that he included more than one species under his variety. I am not certain that the form here named in his honor is not one of them, while the *F. albida*, Hall, and its variety *richfieldensis* of the present paper most likely served in describing the reverse. The specimen from which he prepared his figure of the celluliferous side being apparently in a good state of preservation must have been different from these, since it shows neither a carina nor striæ between the ranges of zooecia. If the figure correctly represents his specimen I should consider it as clearly distinct from the form here called *F. meekana*. On comparing the figures of the last species with Meek's, other differences may be noted, i. e., the zooecia apertures in the latter are more closely arranged, and the fenestrules smaller.

F. meekana is readily distinguished from all Devonian and Carboniferous species of the genus known to me by the large fenestrules. In the absence of a keel the species approaches to the two and three mamed *Polyporæ*.

Formation and locality:—Richfield. A small fragment that may belong to this species occurs on a slab from Lodi, Ohio.

FENESTELLA ALBIDA, Hall.

(Plate XIII, Fig. 3—3c.)

Fenestella albida, HALL. Sixth Ann. Rept. State Geol. N. Y., 1887, p. 48.

Plate VII, Fig. 1–7.

Zoarium large, probably flabelliform, spreading in a plane, or very slightly undulating toward the outer extremity of large fragments. The largest fragment seen is 120 mm. long, and about 50 mm. wide.

Obverse:—Branches very slender, nearly straight, fifteen or sixteen in 10. mm., mostly about 0.35 mm. wide; about 0.25 mm. wide just after, and 0.40 to 0.50 mm. wide just before bifurcating. The branches are sometimes nearly parallel and always diverge rather slowly, the bifurcations occuring at intervals of usually more than 35 mm. and rarely less than 20 mm. *Carina* thin, slightly elevated, with about four small nodes in 5 mm. *Zooecia* in two ranges, sixteen or seventeen in each in 5 mm.,† the two ranges strongly interlocking in the interior. Apertures circular, nearly direct, more than their diam-

†Hall says (loc. cit.) 20, but his figure shows only sixteen in 5 mm.

erage width not 0.38 mm.; bifurcation frequent, the intervals varying between 1 mm. and 4 mm, *Carina* thin, moderately elevated, faintly nodose, the nodes distant from each other about 0.5 mm. *Zooecia* in two ranges, eighteen in each in 5 mm.; apertures circular, 0.11 mm. in diameter, directed a little obliquely upward and outward, with well developed peristome drawn out posteriorly into an oblique ridge, and projecting laterally so as to indent the border of the fenestrule. *Dissepiments* depressed, thin, finely striated, expanding very little at their junction with the branches. Fenestrules irregular in shape and size, with from seven to nine in 10 mm.

On the *reverse* the branches and dissepiments strongly rounded, and covered with short striations, or minute granules. The fenestrules here are wider than on the other side of the zoarium.

This neat species is related to *F. albida* var. *richfieldensis* and *F. filistriata*, Ulrich,* from the Burlington limestone of Iowa. From the former it differs in the smaller zoarium, more flexuous branches, narrower and smaller fenestrules, and more closely arranged zooecia apertures. The *reverse* side of the branches is also differently marked. These differences also apply when compared with the Burlington species, that form being further distinguished by its finely striated obverse.

Formation and locality :—Cuyahoga Valley below second fall.

FENESTELLA SUBFLEXUOSA, n. sp.

(Plate XIII, Fig. 6.)

Zoarium a small leaf-shaped expansion, 20 mm. long and 16 or 18 mm. wide.

Obverse:—Branches slender, laterally compressed, between 0.3 mm. and 0.4 mm- wide, diverging rapidly, irregularly flexuous, seven or eight in 5 mm.; bifurcations frequent, so far as observed, the intervals vary between 1.5 mm. and 6 mm. *Carina* thin, strongly elevated, carrying small but rather prominent nodes 0.2 to 0.3 mm. apart. *Zooecia* in two ranges, seventeen or eighteen in 5 mm.; apertures circular, small, about 0.08 mm. in diameter, nearly direct, surrounded by well developed peristome, a little more than their diameter apart. *Dissepiments* very thin, sharply angular, only a little depressed, not expanding at their junction with the branches. *Fenestrules* of irregular form and unequal sizes, unusually eight in 10 mm.

On the *reverse* the branches are striated longitudinally and rounded.

This form is closely allied to both *F. foliata* and *F. albida* and I am not prepared to hold that more abundant material than has come under my notice will not prove it to be specifically identical with one of them. The characters relied upon in distinguishing it are the more flexuous compressed branches, less depressed dissepiments, the greater prominence of the carina, and the absence of striæ in the longitudinal spaces between the zooecia apertures.

Formation and locality:—Cuyahoga shales, thirty feet below Carboniferous conglomerate at Cuyahoga Falls.

FENESTELLA CAVERNOSA, n. sp.

(Plate XIII, Figs. 7–7b.)

Zoarium strongly folded, probably infundibuliform. All the specimens are fragmentary, the largest about 50 mm. long and 40 mm. wide.

Obverse:—Branches nearly straight, of moderate strength, rather unequal, averaging 0.41 mm. in width.; immediately after bifurcating the width is about 0.3 mm., and just beneath the next division about 0.5 mm., the rate of increase between the two extremes being gradual. The bifurcation occurs at intervals varying betwen 6.0 mm. and 15.0 mm., and not unfrequently take place simultaneously in a number of neighboring branches, causing a considerable variation in the number of branches in a given space. Thus while the average number in 10 mm. is seventeen or eighteen, as few as sixteen and as many as twenty-two may occur in an equal space, on certain portions of a frond. *Carina* small, often slightly sinuous, generally with faint nodes or swellings at rather irregular intervals. Entire surface between zooecia apertures minutely porous, the pores elongate so that they not infrequently cause the surface to appear finely striated. *Zooecia* in two ranges, fourteen or fifteen in 5 mm.; apertures nearly direct, circular, 0.09 mm. in diameter, a greater distance apart, three, occasionally four, opposite each fenestrule, and surrounded by a well developed peristome, sometimes obliquely prolonged posteriorly. In the thinner branches the peristomes project slightly beyond the margin of the branches. *Dissepiments* somewhat depressed, half as wide as the branches, expanding at each end. *Fenestrules* twice as long as wide,

or a little wider than the branches, nine, sometimes ten in 10 mm.

Reverse:—Here the branches are more or less strongly rounded, the dissepiments nearly on a plane with them, and both somewhat thinner, the fenestrules larger than on the opposite face of the zoarium. The whole surface is covered with the sub-angular or elongated orifices of small pores, usually exhibiting a marked tendency to a longitudinal arrangement.

This peculiar species is known only from natural moulds of the exterior, and the characters above described are furnished by gutta-percha impressions. Those showing the obverse side exhibit a feature as yet not well understood, but which I am inclined to attribute to a peculiar state of preservation. The mouths of most of the zooecia are surrounded, namely, by a circular impression instead of a raised margin. This feature appears so anomalous that in preparing figure 7–a I have taken the liberty to substitute (excepting in the upper right hand zooecium) a raised line where the gutta-percha shows an impressed one. If I am right in ascribing this anomalous character to an unusual state of preservation then it is not impossible that the porous condition of the branches and dissepiments is due to the same cause. This, however, is not probable, yet, if true, they must represent structures of some kind—tubercles perhaps.

In its measurements this species approaches closely to *F. Herrickana*. Aside from the supposed differences in the surface markings they differ in the following particulars: *F. Herrickana* has thirteen or fourteen zooecia in 5 mm and seven or eight fenestrules in 10 mm. where *F. cavernosa* has, respectively, fourteen or fifteen and nine or ten.

Formation and locality:—Waverly group, at Sciotoville, Ohio, where it occurs, associated with *Streblotrypa amplexus* and numerous brachiopoda in ferruginous clay nodules.

FENESTELLA REGALIS, Ulrich.

(Plate XIII, Fig. 5, 5a.)

Fenestella regalis, ULRICH. Rept. Ill. Geol. Surv. Vol. VIII, pl. 1, fig. 1, 1a. (now in press.)

All of the Ohio specimens of this species before me are mere fragments. The most of them agree quite closely with the typical

Kentucky examples. Several however, are more delicate and have sixteen instead of fourteen zooecia in the space of 5 mm. The apertures also are a little larger and the peristomes very little developed. The fragment here figured is one of them and shows these features very well. If a name is desirable they may be styled *Fenestella regalis* var. *macer*.

Formation and locality: The types are from shales of the Keokuk group at King's Mountain, Ky., while the Ohio specimens come from the Cuyahoga shale at Richfield and Lodi.

FENESTELLA BURLINGTONENSIS, Ulrich

Fenestella burlingtonensis, ULRICH. Rept. Ill. Geol Surv. pl. XLIX, fig. 1, 1a. (now in press.)

Several worn fragments of a species apparently identical with the Burlington types of this species occur on a small slab from Lodi, O. Associated with them are more or less weathered examples of no less than ten distinct species of Bryozoa, among them *F. regalis*, *Ptilopora paupera*, *Pinnatopora Vinei*, and *Rhombopora incrassata*, all described by me from the Keokuk group of Kentucky and Illinois in the delayed vol. VIII, Illinois Geological Survey.

FENESTELLA TENAX, Ulrich.

Fenestella tenax, ULRICH. Ill. Geol. Surv. vol. VIII, pl. II, figs. 2-2d. (in press.)

Two years ago I received several fragments of fossiliferous rock from Rev. H. Herzer which he had collected in the upper beds of the Waverly series at some locality in Cuyahoga Co. These furnished good gutta-percha impressions of both the *obverse* and *reverse* sides of a small species of *Fenestella* that I cannot now distinguish from the Kentucky and Illinois types of *F. tenax*. This species though probably the most abundant in the Chester limestone, began its existence as early as the formation of the Keokuk group, a number of specimens collected at Keokuk, Iowa, and Nauvoo, Illinois, being, apparently, identical with the Warsaw and Chester examples, as well as with the Ohio specimens now before me.

UNDETERMINED SPECIES OF FENESTELLA.

Among Prof. Herrick's material there are two specimens of a

small flabellate species, forming a rather closely woven network. The species is probably new, but as both show only the *reverse* and, as the characters of the more important opposite could not be ascertained, it is not described. The specimens are from the Cuyahoga shales about thirty feet below the Carboniferous conglomerate, at Cuyahoga Falls.

Another specimen from a layer of ferrugenous freestone at Bagdad shows only the *obverse* and that not in a satisfactory manner. As near as can be determined it belongs to a species either very closely related to or identical with *F. multispinosa*,* Ulrich, a Keokuk species occuring in Kentucky, Iowa and Illinois. It also agrees rather closely with Meek's description of his *F. delicata*, described from nearly the same horizon at Lodi.

Several other species of this genus known to me from the Ohio Waverly series are too imperfect for satisfactory comparisons.

POLYPORA IMPRESSA, n. sp.

(Plate XIII, Figs. 8, 8a.)

Zoarium small, flabellate. *Branches* comparatively slender, between 0.4 mm. and 0.62 mm. wide, about four in 1 mm.; bifurcations frequent, occuring at intervals of from 1 mm. to 5 mm., the intervals being shortest near the base. *Zooecia* mainly in two ranges, but where the distance between the bifurcations is more than 3 mm., a third range is interpolated. *Apertures* small, strongly elevated, with the margin denticulate when perfect. Over at least the upper half of the zoarium there is a large, oval, rather shallow, yet more or less sharply margined impression behind most of the apertures. Near the base of the frond these impressions are either very indistinct or quite obsolete, and the zooecia apertures rise from the surface of the branch very much as in certain species of *Stomatopora* and other *Cyclostomata*.

In the branches with only two ranges of zooecia the apertures are situated along the border of the branch and frequently project a little over it. About fourteen zooecia in each range in the space of 5 mm. *Dissepiments* slender, slightly depressed, finely striated, generally less than half as wide as the branches. *Fenestrules* elongate, varying in shape and size, from 1.5 mm. to 3.0 mm. long, the width equalling generally about half their length and one and a half or two times the width of the branches.

On the *reverse* the branches and dissepiments are evenly rounded and faintly striated.

In the frequent bifurcations of the branches, widely separated dissepiments and general aspect of the zoarium, this species approaches *Thamniscus*, King, and I am inclined to believe that when this group of species, to which *P. gracilis*, Prout, also belongs, is better understood, they will be removed from *Polypora*. In my Illinois work on the bryozoa I have already placed several species of this type with *Thamniscus*, having been able to show that *T. dubius*, Schlotheim, the type of the genus, also, (at least occasionally) has some of the branches united by dissepiments. Much study and an abundance of material is required before a final disposal of these peculiar species is possible.

Taking all its characters into consideration, *P. impressa* is not likely to be confounded with any other species known to me. Similar impressions behind the zooecia apertures are present in the Upper Carboniferous *Thamniscus octonarius*, Ul.* This character is one of rare occurence among palæozoic bryozoa and brings some of the mesozoic and recent forms to mind.

Formation and locality :—Cuyahoga shale of the Waverly series, between 50 and 100 feet below the Carboniferous conglomerate, at Richfield, Summit Co., Ohio. The type specimen is attached to the surface of a small fragment of a ferruginous clay nodule, less than two inches square. With it are more or less fragmentary remains of at least seven other species of bryozoa.

POLYPORA GRACILIS, Prout.

Polypora gracilis, PROUT, 1860. Trans. St. Louis Acad. Sci. vol. I, p. 580.
" " PROUT, 1866, Geol. Surv. Ill. vol. II, p. 422, pl. XXI, figs. 1, 1a.
" " ULRICH, Ibid. vol. VIII, pl. LXI, figs. 10, 10a. (Now in press.)

Two specimens, one from Richfield, the other from Sciotoville, are provisionally referred to this species. The first shows only the reverse, while the second is an illy preserved mould of the obverse. There is, therefore, no certainty that they belong to *P. gracilis*, especially since there are several distinct species of this type in the Burlington and Keokuk limestones.

POLYPORA RADIALIS, Ulrich.

Polypora radialis, ULRICH. Ill. Geol. Surv. vol. VIII, pl. LX, figs. 1, 1d.

Natural moulds in freestone of this small infundibuliform species are abundant in the upper 30 feet of the Waverly series near Newark, Ohio, while a single example was collected by the author in the Cuyahoga shales at Richfield where it was associated with numerous species of crinoids, *Fenestella albida*, *F. aperta*, and species of *Pinnatopora*. There seems no reason to doubt the specific identity of the Ohio specimens with the Illinois and Iowa types. At those more western localities the species is known only from shales of the Keokuk group.

PTILOPORA PAUPERA, Ulrich.

Ptilopora paupera, ULRICH. Ill. Geol. Surv. vol VIII, pl. LXVI, fig. 10.

A fragment of this species occurs on a small slab filled with bryozoan remains of numerous species. Among them I recognize the following: *Fenestella burlingtonensis*, *F. regalis*, *Pinnatopora Vinei*, *Rhombopora incrassata* and *R. confluens*. All of these species are described by me in volume VIII of the Illinois Geo. Surv. reports, now in press, the first from the Burlington limestone, the remainder from shales of the Keokuk group in Kentucky and Illinois. The types of *P. paupera* are also from Keokuk shales. This interesting slab is one of several collected by Prof. Herrick at Lodi, O.

PINNATOPORA INTERMEDIA, n. sp.

(Ptate XIV, Fig. 1.)

Zoarium pinnated. The only specimen seen consists of four primary branches each 2 cms. or more long, that evidently belonged to one zoarium. All present the reverse side to view.

Midrib slender, about 0.3 mm. wide, slightly flexuous, with the *reverse* rounded and striated longitudinally. On the obverse side the two ranges of zooecia apertures are separated by a thin sharp carina, carrying rather distant small nodes. Lateral branches or pinnæ from 1 to 3 mm. long, half as wide as the midrib, often united to each other by very slender non-celluliferous dissepiments, forming an angle of about 50 degrees with the midrib, and numbering ten or eleven on each side in 10 mm. Primary portions of zooecia in two alternating ranges

in the midrib; in the lateral branches they are wedge-shaped and form a single series only. Apertures small, circular, in two ranges, one situated at the base of each lateral branch and two or three between. As near as can be determined, there are about twenty on each side of the midrib in 5 mm

In having the longer lateral branches united by dissepiments this species approaches *Ptilopora*, but the general aspect and growth of the zoarium is so much like *Pinnatopora* that it has seemed advisable to place the species as above rather than under the former genus. If, however, possession of non-celluliferous dissepiments is insisted upon as being the only point of difference between the two groups, then the species will have to stand as *Ptilopora intermedia*. In any event the specific name will indicate the intermediate character of the form.

Compared with other species *P. intermedia* will be found to differ from *Ptilopora vatida*, Ulrich,* from an equivalent horizon in Illinois, in being much more delicate, and from the associated *Pinnatopora tenuiramosa*, Ulrich,* in having the lateral branches less numerous in a given space and directed much more toward the distal extremity of the zoarium. In the last species the pinnæ form an angle of nearly 80° with the midrib.

Formation and locality :—Cuyahoga shales of the Waverly series, at Richfield, O.

PINNATOPORA SIMULATRIX, n. sp.

(Plate XIV, Fig. 3.)

Zoarium pinnate, the reverse only seen. Midrib comparatively strong, about 0.6 mm. wide, somewhat flattened or broadly rounded and very finely striated longitudinally. Lateral branches (pinnæ) depressed, slender, about 0.2 mm. wide, 1 to 2 mm. long, with fifteen given off on each side in 10 mm.; they form an angle of about 70° with the midrib and the longer ones are occassionally united to each other by exceedingly thin dissepiments.

This is another species that simulates *Ptilopora* in having some of the longer lateral branches united by dissepiments. I am, however, inclined to hold that species of the type of this and the preceeding ones cannot be removed from *Pinnatopora* if we propose to make natural affinity the primary disideratum of our classifications. *P. simulatrix*

is closely related to *P. intermedia* but differs in having the reverse more finely striated and more numerous lateral branches in a given space. *P. intermedia* has them more oblique and less numerous.

Formation and locality:—Same as the preceeding.

PINNATOPORA CURVATA, n. sp.

(Plate XIV, Fig. 4.)

Zoarium pinnate, reverse aspect only observed. Midrib straight, about 0 4 mm. wide, rounded and finely striated Pinnæ about eight on each side in 10 mm., unusually oblique, forming an angle of 45° with the midrib; they are from 1 to 2 mm. long, curved and about half as wide as the midrib.

So far as observed, this species differs from *P. striata*, Ulrich,* from the Keokuk group of Iowa, in the curved and more oblique pinnæ. Of the latter also there are eight where that species has seven. *P. flexuosa*, Ulrich,* from the same horizon in Kentucky has the lateral branches separated by even longer intervals. There are five or six in 10 mm. *P. intermedia* is a more delicate species and has ten or eleven lateral branches in 10 mm.

Formation and locality:—Same as the preceeding.

PINNATOPORA SUBANGULATA, n. sp.

(Plate XIV, Fig. 2.)

Zoarium pinnate. Midrib nearly straight, between 0.3 mm. and 0.4 mm. wide, with the reverse side more or less angular and marked by from three to five longitudinal striæ of which the central one is the strongest. Pinnæ straight, between 1 and 2 mm. long, about half as wide as the midribs, with usually twelve, sometimes eleven or thirteen in 10 mm.; they form an angle of from 65° to 70° with the midrib, and on the reverse side are finely striated. On old examples the striæ on both midribs and pinnæ bear rows of minute granules. Zooecia in two ranges, about nineteen on each side of the midribs in 5 mm., with one opposite each lateral branch and two in the space between. Apertures circular, surrounded by a distinct peristome, their diameter or less apart. Intermediate spaces very finely granulo-striate. Carina moderately developed, rather rounded than sharp, with nodular swellings at intervals corresponding nearly to the length of a zooecium.

The sub-angular character of the reverse distinguishes this species from all others known to me. In other respects it resembles *P. tenuiramosa* very closely. *P. Vinei* also is a nearly related species but, aside from the different form and markings of the reverse. is distinguished by the smaller number of pinnæ and zooecia in a given space.

Formation and locality:—Cuyahoga shales of the Waverly series, about 30 feet below the Carboniferous conglomerate at Cuyahoga Falls.

PINNATOPORA MINOR, n. sp.

(Plate XIV, Fig. 7, 7a.)

Zoarium very small, pinnate. Midrib about 0.32 mm. wide, throwing off the pinnæ sub-alternately from the two sides, at an angle of nearly 80°. The latter are short, less than 1 mm. long, about 0.19 mm. wide, and eight or nine on each side in 5 mm. Reverse side of midrib broadly rounded or somewhat flattened along the middle, and marked by three fine longitudinal striæ, bordered on each side by a smooth space, Obverse face ridge-shaped, the carina comparatively strong and bearing inconspicuous nodes at intervals a little longer than a zooecium. Zooecia in two ranges, with subcircular or elliptical apertures, about 0.09 mm. in diameter, with moderately developed peristome, much the highest on the outer side. The apertures are arranged one at the base of each lateral branch and one in the intermediate space, with about sixteen on each side of the midrib in 5 mm.

This neat species resembles *P. Youngi*, Ulrich,* in nearly every respect excepting size, that being one of the most robust forms of the genus while this is one of the smallest. Its diminative fronds are easily distinguished from the associated species.

Formation and locality:—Upper beds of the Cuyahoga shales, at Richfield, O.

PINNATOPORA VINEI, Ulrich.

(Plate XVI, Fig. 5.)

Pinnatopora Vinei, ULRICH. Ill. Geol. Surv. vol. VIII, pl. LXVI, figs. 5, 5b. (In press)

I cannot see that the Ohio specimens of this species differ in any essential respect from the Kentucky and Illinois types. Being one of

ulatrix. another closely related form has fifteen lateral branches in 10 mm. and the larger ones sometimes united by a dissepiment.

Formation and locality:—Cuyahoga shales of the Waverly series at Richfield, O.

TÆNIODICTYA INTERPOLATA, n. sp.

(Plate XIII, Figs. 9, 9a.)

Zoarium bifoliate, ramose; dividing dichotomously or otherwise at frequent but unequal intervals, the extremes noticed being 4 mm. and 15 mm. Branches acutely elliptical in transverse section, 2.5 to 3.0 mm. wide, and about 0.5 mm. thick. Margins sharp, narrow, granulo-striate. Zooecia arranged in diagonally intersecting curved lines and in more or less regular longitudinal series, those near the border a little larger than those in the central region of a branch. The longitudinal arrangement is more pronounced in some examples than in others. Apertures elliptical, sometimes nearly circular, comparatively large, averaging 0.25 mm. long by 0.18 mm. wide. When the arrangement is regular the ends of the apertures are separated by either one transversely elongated pit or mesopore or by two small ones. On some examples or portions of their surface the pits are more numerous and somewhat irregularly distributed. The interspaces or walls between the zooecia apertures and mesopores are comparatively thin and obtusely ridge-shaped. Measuring longitudinally about fourteen zooecia occur in 5 mm.; diagonally ten or eleven in 3 mm.

The minute internal structure of the walls is very much like that of *T. ramulosa*, the type of the genus.

The intermediate pits that distinguish this species from the three forms upon which I established the new genus *Taeniodictya* in my forthcoming Illinois work lends this species a resemblance to *Stictoporella*. That genus, however, is essentially a Lower Silurian group and, though I place Lower Carboniferous forms under it, I am strongly inclined to question the propriety of the arrangement. Until an exhaustive study of the palæozoic bifoliate bryozoa is made the arrangement of species under the various genera must be regarded as tentative, and as the form under consideration presents no very marked deviation from the typical species of the proposed genus *Taeniodyctia*, the wisest course for the present seems the one here adopted.

Formation and locality:—Cuyahoga shales. This species was

first brought to my notice several years ago by Rev. H. Herzer of Cleveland, O. Since then I have collected it myself at Richfield, O. Rev. Herzer's were collected by him at localities in Cuyahoga Co.

CYSTODICTYA ZIGZAG, n. sp

(Plate XIII, Fig. 11, 11a.)

Zoarium bifoliate, ramose, consisting of a main branch either nearly straight or more or less zigzag, from 1.3 mm. to 2.3 mm. wide, which throws off sub-alternately from the sides somewhat narrower branches. The latter may remain simple or become divided in a manner similar to the main branch. The lateral branches, if they may be so called, are given off at intervals of about 4 mm., so that about three occur on each side of a main branch in 20 mm. Zooecia in six to eight rows on the main branches and in six or seven on the lateral ones; apertures widely separated, small, subelliptical, with a moderately developed peristome, highest on the outer or lunarial side; as a rule they are not regularly arranged but sometimes curved diagonal and longitudinal rows may be determined with distinctness. Usually about ten occur in 5 mm. longitudinally and between six and seven in 3 mm. diagonally. Interspaces rather wide; in young or macerated specimens exhibiting sinuous striæ; in old examples either smooth or covered with exceedingly minute granules.

This species is distinguished from others of the genus by the peculiar growth, it being the only one known to me branching in the manner above described.

Formation and locality:—Cuyahoga shales of the Waverly series at Richfield O.; also in the Keokuk group at Keokuk, Iowa.

CYSTODICTYA SIMULANS, n. sp.

(Plate XIII, Fig. 10.)

Zoarium bifoliate, ramose, branching dichotomously at intervals of 8 mm. more or less. Branches acutely elliptical in cross section, from 2.8 mm. to 4.0 mm. wide, margined on each side with a narrow non-celluliferous strip. Zooecia apertures rather large, subcircular, with a strongly elevated and rather thick peristome when fully matured. The apertures are often arranged in more or less curved transverse rows, which may extend completely across the width of a branch

or terminate near the middle. Where this arrangement prevails the peristomes of neighboring apertures coalesce and form what may be termed beaded ridges. In these transverse rows five apertures occur in 2 mm. and from six to eight suffice to cross the branch; measuring longitudinally, eight or nine rows occur in 5 mm. In other examples, an arrangement in fairly regular longitudinal and diagonally intersecting series is evident. In these, nine apertures occur in 5 mm. lengthwise, and six in 5 mm. diagonally. In all the diameter of the apertures situated near the borders is a little greater than that of those near the center of a branch. Sub-centrally perforated opercular covers close many of the zooecia orifices on the specimen illustrated on Plate XIII. Interspaces smooth or very finely granulo-striate.

The position of this species is intermediate between *C. occelata*, Ulrich, and the Coal Measure species *C. carbonaria*, Meek.

Formation and locality :—Waverly group at Moot's Run, Licking Co., Ohio, about 200 feet below the top of the series. Also in the Keokuk group at Warsaw, Ill., and Keokuk, Iowa.

CYSTODICTYA ANGUSTA, sp. n.

Plate XIV, Fig. 20.

Of this species I have seen only small fragments of which the largest is figured. None of them show any indication of having been branched. The basal portion is preserved on one of them. This grew around some slender foreign object, is comparatively large, and exhibits irregularly distributed apertures of a number of zooecia. From one side there arises a free branch like the fragment illustrated. The latter presents the following characters: It is between 0.8 and 0.9 mm. wide, 0.5 mm. thick, sub-elliptical in cross section, curved, with the margins narrowly rounded and granulo-striate. The surface presented to view has two rows of zooecia apertures, with twelve in each row in 5 mm. By removing a portion from the matrix it has been ascertained that the opposite side bears three rows. The zooecia apertures are subcircular, rather large, about 0.18 mm. in diameter and surrounded by slightly elevated thick peristomes. The surface between the rows of apertures is rounded or sub-angular and presents several interrupted sinuous striæ or series of granules. The longitudinal spaces between the zooecia apertures is transversed by one

or two oblique granulose striæ. Sub-centrally perforated opercular covers close many of the orifices.

This interesting species can scarcely be confounded with any other known to me. Its narrow branches and only two and three rows of comparatively large subcircular zooecia apertures distinguish it from *C. americana*, Ulrich,* *C. paralella*, Phillips, in which the zooecia form from three to six rows and have narrower apertures arranged between rounded ridges.

Formation and locality:—Waverly group at Moot's Run, Licking Co., Ohio. Collection of Prof. Herrick.

CYSTODICTYA, sp. undet.

Among the material sent me for examination by Prof. Herrick there are a number of beatifully preserved fragments of a species of *Cystodictya* collected by him in Moot's Run, a very interesting locality in Licking Co. As I do not intend to name the form I might have left them without remark were it not for the fact that the same variety also occurs in the Keokuk group of Illinois. In arranging my collections from those western localities I placed the form as a variety of my *C. lineata*, and that may be its true position. Still, both the Ohio and Illinois examples of the variety are easily distinguished from the typical specimens of that species in wanting the prominent rounded longitudinal ridges that suggested the name *lineata*. The variety differs further in having more nearly circular, though still oval, and larger zooecia apertures and more distinct peristomes. The lunarium also is not so strongly developed. On the whole, therefore, I believe that when this difficult group of bryoza has undergone the careful revision now but fairly begun by me, characters will be found to distinguish at least three or four species among the material now classed as varieties of *C. lineata*.

GLYPTOPORA MEGASTOMA Ulrich.

Glyptopora megastoma, ULRICH. Ill. Geol. Surv. vol. VIII, pl. LXXVIII, figs. 5, 5a (In press.)

Two specimens from Sciotoville, where they were found associated with *Spirifera striatiformis*, Meek, *Streblotrypa amplexa*, Ulrich,

and *Fenestella cavernosa*, Ulrich, are referred to this species. The types are from the Keokuk group of Illinois and Iowa. In the collection of E. O. Ulrich.

STREBLOTRYPA MAJOR,† Ulrich.

(Plate XIV, Fig 10.)

Streblotrypa major, ULRICH. Ill. Geol. Surv. vol. VIII, pl. LXXI, figs. 8, 8d, and pl. LXXII, figs, 1, 1a.

The following description of this species is copied from my MS. for the above work: "Zoarium a comparatively robust, dichotomously or otherwise divided stem. Often found flattened from pressure. The divisions of the branches occur at long intervals and are often unequal. Zooecia apertures oval, 0.25 mm. long and about 0.15 mm. wide, surrounded by a narrow sloping area, only noticeable in perfect specimens; arranged in longitudinal series (interrupted at more or less frequent intervals) between subangular longitudinal ridges, that are not distinct from the aperture margin but form their lateral boundaries. The longitudinal interspaces between the succeeding zooecia apertures exhibit the mouths of from one to three short ranges of mesopores. These pores vary considerably in size, and in number from three to twelve, but when the zooecial arrangement is regular, their number is generally either four or six. Measuring longitudinally, about ten zooecia apertures occur in 5 mm."

"Of internal characters, the comparative shortness of the zooecial tubes, the non-development of an inferior hemiseptum, and the rather irregular appearance of the tubes in the axial region, are the most noteworthy."

"The large zooecia and rather robust zoarium easily distinguished this species from all others of the genus known to me."

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†The genus *Streblotrypa* was proposed in MS. by me several years ago, and specimens of the type species, *S. Nicklesi*, (Ill. Geol. Surv. vol. VIII), were sent to students of palæozoic bryozoa. The name was adopted for a supposed variety of the type species by Mr. G. R. Vine, in 1886. (Notes on the Joredale Polyozoa of North Lancashire). During November or December, 1887, there appeared vol. VI of the Palæontology of N. Y. In looking over this fine work I find that Prof. Hall has placed at least one species under his new genus *Acanthoclema* that ought rather to be regarded as a form of *Streblotrypa*. The species referred to is the *Ceriopora hamiltonensis* of Nicholson. The typical species of *Acanthoclema* are quite different, being, like his sub-division *Orthopora*, closely related to *Rhombopora*.

The Ohio examples of this species are somewhat smaller than the Kentucky types, but there can be no question of their specific identity.

Formation and locality:—Keokuk group at King's Mountain, Ky., and Keokuk, Iowa. The Ohio examples are from the Cuyahoga shales at Richfield, O. Collection of E. O. Ulrich.

STREBLOTRYPA OBLIQUA, n. sp.

(Plate XIV, Fig. 9.)

This species or variety of *S. major* is represented by but a single example which has suffered somewhat through compression. It consists of a nearly straight stem about 2.5 mm in diameter, and 25 mm. long, widening at the upper extremity where it is broken, as though a bifurcation was about to take place. The zooecia apertures open obliquely, are large, oval, 0.20 mm. long by 0.13 mm. wide, and, though a little more crowded and irregular, are arranged much as in *S. major*. In the rather irregular longitudinal series nine or ten zooecia occur in 5 mm.; measuring diagonally eight or nine in 3 mm. The apertures of the zooecia are situated at the bottom of sloping areas, with the slope gentle and widest above, giving them the appearance of being drawn out trough-like. At posterior margin there is a slightly elevated thin lip. The top of the areas of adjoining zooecia unite to form irregular and more or less sharply angular longitudinal ridges. The mesopores are rather irregularly arranged though mainly situated between the ends of the zooecia apertures. They number two, three or four to each zooecium.

This form is closely allied to S. major and may represent only a variety of that species. The only specimen seen however, appears so different in its thicker interspaces, oblique zooecia apertures and less abundant mesopores that another designation seems necessary.

Formation and locality:—Cuyahoga shales of the Waverly series at Lodi, O. Collection of Prof. C. L. Herrick.

STREBLOTRYPA HERTZERI, n. sp.

(Plate XIV, Fig. 8.)

Zoarium consisting of remotely bifurcating stems, about 2 mm. in diameter. Zooecia apertures direct, oval or subcircular, large, rather

unequal, 0.25 to 0.38 mm. in length, arranged in not very regular diagonally intersecting and longitudinal series, nine in 3 mm. diagonally and ten in 5 mm. longitudinally. Sloping area very narrow. Walls thin, mesopores irregularly distributed, sometimes forming small clusters of ten or more, around which the zooecia are often larger than usual. Normally from two to six mesopores occupy a variously shaped space back of each zooecium, so that the latter is in contact with four other zooecia. Internal structure not observed.

This species is nearly related to *S. major*, Ulrich, but the thinner walls and the absence of longitudinal ridges serve to distinguish it. *S. obliqua* has much thicker walls and oblique zooecia apertures; *S. amplexa* more abundant mesopores and smaller zooecia.

Rev. H. Herzer of Cleveland, O., was the first to bring this species to my notice, and I take the opportunity of naming it for him as a slight token of my appreciation of the uniform kindness and generosity which he has always extended to me.

Formation and locality:—Cuyahoga shales of the Waverly series at Richfield, Lodi and several localities in Cuyahoga Co., Ohio. Very rarely also in the Keokuk group at Keokuk, Iowa. Collection of E. O. Ulrich.

STREBLOTRYPA AMPLEXA, n. sp.

(Plate XIV, Fig. 13.)

Zoarium consisting of remotely bifurcating stems, 1.7 mm. to 1.9 mm. in diameter. Bifurcations 20 mm. or more apart. Zooecia apertures direct, broad oval, of moderate size, 0.15 to 0.22 mm. in their larger diameter, arranged in rather regular diagonally intersecting series, with six in 2 mm.; measuring longitudinally ten or eleven occur in 5 mm. Sloping area and walls of moderate thickness. Mesopores abundant, completely isolating the zooecia; averaging six or seven to each zooecium.

Internal structure unknown.

This species stands intermediate between *S. Hertzeri* and *S. multiporata*. From the former it differs in having smaller zooecia apertures and more abundant mesopores, from the latter in having the zooecia larger and the mesopores less numerous.

Formation and locality: Waverly group. The natural moulds of this fine species were quite abundant near Sciotoville, O.

STREBLOTRYPA MULTIPORATA, n. sp.

(Plate XIV, Fig. 11.)

Zoarium ramose, the stems somewhat irregularly cylindrical, about 1.7 mm. in diameter. Zooecia apertures direct, subcircular, of unequal sizes, 0.08 to 0.15 mm. in diameter, irregularly arranged, sometimes scarcely distinguishable from the mesopores. Mesopores very abundant, completely isolating the zooecia, often arranged in interrupted longitudinal series. Two or three of these rows are generally arranged between short ridges Walls and sloping areas of moderate thickness.

The smaller zooecia and exceedingly numerous mesopores distinguish this species from *S. amplexa*, its nearest congener.

Formation and locality:—Waverly group. Moot's Run, Licking Co. Ohio.

Prof. C L. Herrick's collection.

STREBLOTRYPA STRIATA, n. sp.

(Plate XIV, Figs. 12, 12a.)

Of this species I have four fragments varying from 6 to 15 mm. in length and 0.5 to 0.9 mm in diameter. None of them are branched. The surface is traversed by strong parallel longitudinal ridges which may continue in a nearly straight line for a considerable distance. At other times they are frequently interrupted, and sometimes assume slightly oblique or sinuous directions. Between these ridges which carry prominent nodes at irregular distances apart, the zooecia apertures are arranged. The latter are oval, about mm. long and mm. wide, and surrounded by a well developed peristome. The concave space between succeeding apertures and the principal ridges is usually occupied by one or two finer striæ About† occur in 5 mm. measuring longitudinally.

On old examples it is difficult to make out the zooecia, the peristomes being less distinct than in younger specimens, and the whole surface appears finely striated longitudinally.

This very neat and distinct species may be compared with *S. multiporata* and *S.* (?) *denticulata*. Its stems are more slender than those

†It was discovered too late for correction that these measurements had been omitted in the MS. C. L. H.

species are not in a very good state of preservation and better specimens may prove that my figures of them are defective in not showing a sloping area and in having the zooecia apertures too large.

Formation and locality :—The Ohio specimens are from the Cuyahoga shales at Lodi; the types of both *R. incrassata* and *R. spiralis* are from the Keokuk group at King's Mountain, Ky.

Collection of Prof. C. L. Herrick.

RHOMBOPORA OHIOENSIS, n. sp.

(Plate XIV, Fig. 4.)

Compare *Rhombopora dichotoma*, ULRICH. Ill. Geol. Surv. vol. VIII, pl. LXX, figs. 13, 13b.

Zoarium ramose, bifurcation distant. Branches cylindrical, between 1.0 and 1.3 mm. in diameter. Zooecia apertures arranged in longitudinal and diagonally intersecting series, oval, small in the old state, longer when young, the diameter becoming smaller with age by an internal deposit of sclerenchyma. Interspaces ridge-shaped, more acute in the young than in the fully matured state. The interspaces form sinuous ridges, alternately approaching and diverging from each other; rarely coalescing, usually leaving a narrow depression between the ends of the sloping areas that surround the zooecia apertures. Summit of ridges with a row of small tubercles (acanthopores?). measuring longitudinally ten or eleven zooecia occur in 5 mm.; diagonally seven in 2 mm. The diagonal rows intersect each other at an angle of about 65°.

The form briefly described above is so much like *R. dichotoma*, Ulrich, from the Burlington limestone of Iowa that I am strongly inclined to regard is as only a local variation of that species. The number of zooecia in a given space and the general aspect of the surface is the same, the only differences observed being the greater frequency of the narrow sulcus between the ends of the cells, the more acute angle at which the diagonal rows intersect each other and the smaller diameter of the branches.

A still smaller form, with more frequently bifurcating branches, 0.7 or 0.8 mm. in diameter, occurs at the Richfield, Lodi and Burbank exposures. Whether this should be separated from *R. Ohioensis* is as yet undetermined. It agrees very closely (so also does *R. Ohioensis*) with a common species of the Keokuk group of Iowa and Illi-

nois. More study than I can give them now is necessary before the inter-relations of these closely allied forms can be determined with anything even approaching satisfaction.

Formation and locality:—Cuyahoga shales of the Waverly series at Richfield, Lodi, Cuyahoga Co., and Moot's Run in Licking Co., Ohio. Those from the last locality are derived from strata occupying a lower horizon in the series.

Prof. C. L. Herrick's and E. O. Ulrich's collections.

RHOMBOPORA CONFLUENS, Ulrich.

(Plate XVI, Fig. 17.)

Rhombopora confluens, ULRICH. Geol. Surv. Ill. vol. VIII, pl. LXX, figs. 5,5b. (In press.)

The Ohio specimens are larger and the small node below the aperture is usually absent, while the sinuous longitudinal ridges appear as though they had borne a row of minute granules, and coalesce more often than is the case in the type specimen of the species. None of these differences are of sufficient importance to cast doubt upon their specific identity.

Formation and locality:—The original examples come from the upper beds of the Keokuk group at Warsaw, Ill. The Ohio specimens from the Cuyahoga shales at Lodi.

Among the Richfield and Lodi material I can make out at least two species of *Rhombopora*. These, as they could not be illustrated, have not been studied very carefully. One of them seems closely related to a Burlington limestone species. (*R. gracilis*, Ulrich,*).

LEIOCLEMA PUNCTATUM.

Callopora punctata, HALL, 1888. Pal. Iowa, vol. I, pt. 2, p. 653.
Leioclema punctatum, ULRICH, 1882. Jour. Cin. Soc. Nat. Hist. vol. V, pl. VI, figs. 1, 1a.
Leioclema punctatum, ULRICH, 1882. Ill. Geol. Surv. vol. VIII. (In press.)

A mould of the exterior in freestone from the Cuyahoga valley below the second falls, represents, probably, this common Keokuk species. The gutta-percha casts agree exactly with slightly weathered examples of the species from many localities in Illinois and Iowa.

LEIOCLEMA GRACILLIMUM, Ulrich.

Leioclema minutum, ULRICH. Ill. Geol. Surv. vol. VIII, pl LXXV, fig. 6, 6a. (In press.)

A small fragment attached to a slab from Lodi differs in no appreciable respect from the Illinois and Iowa examples upon which this species is founded. At those more western localities the species ranges from the Burlington limestone upwards to the top of the Keokuk group.

FISTULIPORA, sp undet.

Three species of this genus are known to me from the Waverly group of Ohio. None of them have been sufficiently examined to determine their relations. One, from the Sciotoville beds, is a ramose species like *F. compressa*, Rominger, but not identical with it. Another, from the same horizon and locality, is parasitic. The third, from Richfield, O., a small discoid species with rather large, oval zooecia is attached to the frond of *Polypora impressa* figured on Plate XIII.

STENOPORA, sp. undet.

A fragment of a ramose species of this genus closely related to *S. montipora*, Ulrich,* from the Keokuk group of Iowa, was found by me near Richfield, O., in the Cuyahoga shale about twenty feet below the conglomerate.

PLATE XIII.

Fig. 1. *Fenestella Meekana*, n. sp. ---------- p. 64.

1. A specimen of the natural size from Richfield, O. Coll. of E. O. U.

1*a*. Portion of obverse of same x 9

1*b*. One branch of same x 18, showing striations and opercular covers in three of the zooecia apertures.

Fig. 2. *Fenestella Herrickana*, n. sp. ---------- p. 63.

2. A fragment of this species of the natural size. Coll. of C. L. H.

2*a*. Obverse side of same x 9.

2*b*. One branch of 2*a* x 18, to show more clearly the ornamentation and opercular covers.

2*c*. Reverse of same x 9, showing the longitudinally striated condition.

2*d*. A branch of another specimen x 18, showing the reverse side in the old condition where the striæ have become obsolete and the whole surface covered with minute granules.

Fig. 3. *Fenestella albida*, HALL. ---------- p. 65.

3. A specimen of the natural size belonging to the variety of *Richfieldensis*. The irregular growth often seen in the variety is unusually striking in this specimen. Coll. of C. L. H.

3*a*. Portion of same x 9, showing the subcarinate character of the reverse.

3*b*. Small portion of the obverse face of another specimen x9.

5*c*. A branch of 3*b* x 18, to show the characters more clearly.

Fig. 4. *Fenestella foliata*, n. sp. ---------- p. 67.

4. A nearly complete zoarium of this species of the natural size. Coll. of Prof. C. L. H.

4*a*. Portion of a specimen showing obverse face x 9.

4*b*. A branch of 4*a* x 18.

4*c*. Several branches from near the base of fig. 4 x 9, showing reverse side.

Fig. 5. *Fenestella regalis*, ULRICH. ---------- p. 70.

5. A small fragment of this species x 9, having thinner branches and larger cell apertures than usual.

5*a*. A branch of same x 18 to show the surface markings more clearly.

Fig. 6. *Fenestella subflexuosa*, n. sp. ---------- p. 68.

6. Obverse of a gutta-percha cast of this species x 9, showing the widely separated zooecia apertures, but little depressed dissepiments and finely nodose carina. Coll. of Prof. C. L. H.

Fig. 7. *Fenestella cavernosa*, n. sp, ---------- p. 69.

7. A fragment of the natural size. Coll. of E. O. U.

7*a*. A branch showing the obverse side x 18.

7*b*. Portion of the reverse of another example x 9, showing the porous character of this face of the zoarium.

Fig. 8. *Polypora impressa*, n. sp. ..... p. 72.
8. A nearly entire zoarium of the natural size. A small species of *Fistulipora* is attached to it. Coll. of E. O. U.
8*a*. One branch of same x 18, showing the strongly elevated denticulate mouths of the zooecia and the large depression beneath each.

Fig. 9. *Tæniodictya interpolata*, n. sp. ..... p. 80.
9. A gutta-percha cast of a mould in ferruginous freestone, natural size. Coll. of E. O. U.
9*a*. Surface of another specimen x 18, showing the form and arrangement of the zooecia and intermediate pits.

Fig. 10. *Cystodictya simulans*, n. sp. ..... p. 81.
10. A specimen of the natural size, showing the arrangement of the zooecia. Coll. of Prof. C. L. H.

Fig. 11. *Cystodictya zigzag*, n. sp. ..... p. 81.
11 and 11*a*. Two fronds of this species, natural size, showing variations in the mode of branching and in the width of the branches.

PLATE XIV.

Fig. 1. *Pinnatopora intermedia*, n. sp. ..... p. 74.
1. A specimen of natural size, showing the reverse and a portion x 9, showing the dissepiments and, where the zoarium has been removed, a mould of the opposite face. Coll. of E. O. U.

Fig. 2. *Pinnatopora subangulata*, n sp. ..... p. 76.
2. A specimen of natural size, showing the reverse and a portion x 9, showing the subcarinate characters of this face of the zoarium. Coll. of Prof C. L. H.

Fig. 3. *Pinnatopora simulatrix*, n. sp. p. ..... 75.
3. A specimen of natural size, showing the reverse and a portion x 9. The latter shows the somewhat flattened character of the midrib and on one side pinnæ connected by slender dissepiments. Coll of E. O. U.

Fig. 4. *Pinnatopora curvata*, n. sp. ..... p. 76.
4. A specimen of natural size, and a portion of same x 9. The figure shows the strong upper direction and slightly curved form of the pinnæ Coll. of E. O. U.

Fig. 5. *Pinnatopora Vinei*, ULRICH. ..... p. 77.
5. A specimen x 9, showing the character of the obverse face on the upper half and of the reverse face in the lower half. Coll. E. O. U.

Fig. 6. *Pinnatopora youngi*, ULRICH. ..... p. 78.
6. A specimen x 9, showing the obverse side. Coll. E. O. U.
6*a*. An unusually strong specimen of the natural size. Coll. of Prof. C. L. H.

Fig. 7. *Pinnatopora minor*, n. sp.----------p. 77.
7. A fragment of the natural size and its obverse side x 9.
7*a*. A fragment showing the characters of reverse, natural size and x 9. Coll. E. O. U.

Fig 8. *Streblotrypa Hertzeri*, n. sp.----------p. 85.
8. A fragment of the natural size with a portion of the surface x 18, showing the arrangement of the large zooecia and mesopores. Coll. E. O. U.

Fig. 9. *Streblotrypa obliqua*, n. sp.----------p. 85.
A branch of this species with a portion of its surface x 18, showing the thick walled zooecia, their oblique apertures and the arrangement of the mesopores. Coll. Prof. C. L. H.

Fig. 10. *Streblotrypa major*, ULRICH.----------p. 84.
10. A fragment of a small specimen of this species, natural size and a portion x 18. Coll. of E. O. U.

Fig 11. *Streblotrypa multiporata*, n. sp.----------p. 87.
11. A branched fragment of the natural size and a portion of the surface of same x 18, showing the small zooecia apertures and very numerous mesopores. Coll. of Prof. C. L. H.

Fig. 12. *Streblotrypa striata*, n. sp.----------p. 87.
12. The lower portion of a fragment of this species x 18, showing the appearance of the surface when the arrangement of the zooecia and ridges is regular.
12*a*. The upper end of same fragment x 18, exhibiting a somewhat less regular arrangement of the ridges. Coll. of E. O. U.

Fig. 13. *Streblotrypa amplexa*, n. sp. ----------p. 86.
13. Portion of a fine ramose example of this species with a portion of the surface x 18 to show the arrangement and comparative size of the zooecia and mesopores. Coll. of E. O. U.

Fig. 14. *Streblotrypa regularis*, n. sp.----------p. 88.
14. Fragment of this species of the natural size and x 18, showing the shallow pits and other peculiarities of the species. Coll. of Prof. C. L. H.

Fig. 15. *Rhombopora ohioensis*, n. sp.----------p. 90.
15. A specimen from the ferruginous freestone layers of the Cuyahoga shales showing the appearance of the surface in the young state x 18.
15*a*. A branched fragment of natural size and a portion of its surface x 18, showing the fully matured appearance of the zoarium. Coll. of E. O. U.

Fig. 16. *Rhombopora incrassata*, ULRICH. ----------p. 89.
16. A specimen of the natural size and a portion of the surface x 18, showing the usual appearance in well preserved specimens of this species.

16*a*. A specimen doubtfully referred to this species, natural size, with a small portion of its surface x 18, showing the openings of one or more series of small pores between the zooecia apertures. Coll. of Prof. C. L. H.

Fig. 17. *Rhombopora confluens*, ULRICH.----------p. 91.

17. A specimen of the natural size with a portion of its surface x 18. The small granulations shown near tbe bottom of the figure are seen on another specimen. Coll. of Prof. C. L. H.

Fig. 18 and 19. *Streblotrypa* (? *Leioclema*) *denticulata*, n. sp.----------p. 88.

18. An unbranched fragment, natural size, with the surface x 18. The latter shows the denticulate apertures and striated interspaces characterizing the species

19. A branched specimen having the surface somewhat abraded, which is referred to the species. Natural size. Coll. of E. O.U.

Fig 20. *Cystodictya angusta*, n. sp. ----------p. 82.

20. Fragment natural size and a portion of the surface x 18, showing two rows of zooecia, irregular striations and fine granules. Also a transverse section x 6. Coll. of Prof. C. L. H·

GEOLOGY OF LICKING COUNTY, O. PART IV.

By C. L. Herrick.

Waverly Group. Continued.

[General Conclusions.]

In concluding the list of fossils for the present it remains, in fulfillment of the promise made at the beginning, to express the opinions to which the study has led us. The discussion cannot be confined to Licking county and a large amount of collecting and stratigraphical study has been done in all parts of the Waverly domain in Ohio, as well as in Pennsylvania, and western New York. Only the briefest outline of this work could be admitted and the reader is asked to believe that the statements of fact presented have all been made after patient labor. Too many distinguished pens have already traversed the question for the writer to venture largely into speculation simply, but he is not without hope that some of the suggestions offered may meet the approval of those prepared to sift the evidence.

A great deal of confusion exists as to the actual sequence of strata in Ohio and the equivalence of beds in different parts of the state. No pains has been spared to determine the exact stratigraphical position of every fossil described and in this we have been unexpectedly successful. Our study sufficiently proves that in its various portions the Waverly presents the same sequence of species and that, casting aside a few species ot great vertical range, these forms are rather sharply limited in definite horizons.

It is deeply to be regretted that for the purpose of correlating the horizons of the Waverly the reports of the Ohio Geological Survey are quite unavailable. Made up as they were by various hands, it is quite impossible to recognize a given horizon of one county in even the adjacent one. Diversity of nomenclature is the least of the difficulties encountered. It was of course impossible for this to be otherwise under the conditions imposed. It is hoped that the correlated horizons here presented may assist in supplying the deficiency.

Perhaps the greatest source of ambiguity in the report of the

geologists of Ohio grew out of the attempt to construe certain local thickenings of the conglomerates of the Waverly. These we explain tentatively as deposits at the mouth of rivers and, in conformity to this theory, trace them as narrow bands of a tortuous character, extending, for example, north-westward from east Licking to west Knox and Richland counties. Wherever such disturbing factors enter, one seeks in vain for familiar landmarks, but a very few miles on either side reveals the well-remembered sequence. The term "Waverly conglomerate" of the Ohio geologists stands merely for such local developments and the admission of this element, often with the remainder of the series as seen near by, or occasionally without it, produces the most abnormal variations in the general sections.

This fact by no means depreciates the labors of the geologists in question, it was an unavoidable incident to the plan necessarily followed. Notwithstanding, for many purposes, just that opportunity to determine the relative position of a stratum in one part of the state with another in a distant county, is of greatest practical and theoretical importance.

Before beginning such a discussion as the present one it is well to have clearly defined the ruling principles upon which the investigation is based, we therefore premise the following:

Geological Aphorisms.

1. Palæontological determinations, to possess the highest value, must be accompanied by minute vertical and acurate geographical data.

2. Lithological determinations in sedimentary rocks are only valuable in connection with detailed palæontological and orographical study.

3. It must be remembered that the palæontological study of a single section, no matter how complete, gives no opportunity for the tracing of the genesis or history of a species. At most it gives only a series of disconnected instantaneous photographs of the species as it was at widely separated times under very diverse conditions.

4. To study the phylogeny of a group it will be necessary to follows it in its migrations as it continually seeks to preserve constant the fluctuating bathymetric conditions.

5. Strata of similar lithological character, even if separated by a considerable vertical interval, may more closely resemble each other

in fauna than those of different lithological character lying closer together or even between them. (That is, vital conditions may much more rapidly change along the shore than in deposits of the same age out at sea.)

Thus in the study of the phylogeny of the fauna of a shale, it should be compared with that of the next following shale and not of the intervening sandstone, but it must be remembered that the period intervening is probably represented by the deposits of the same bed in the direction of the encroachments of an ascending sea or the flight of a retreating one.

6. Opposite sides of the same basin may vary greatly in fauna.

4. Adjacent basins of the same age are rarely identical in fauna and it may be that the most abundantly represented species of these basins are unlike while the rarer species are identical, the latter therefore being most reliable age-indices.

8. It is to be expected that opposite sides of the same basin will possess vicarious species or varieties, and that corresponding sides of separate basins may be more nearly alike than adjacent sides.

9. Adjacent basins may have their strata intermingled along the margin through the agency of unequal oscillation of the sea bottom in the several basins. Then there will result the spurious appearance of an alteration of faunæ in one terrane when in reality, instead of the consecutive strata representing changes in one basin, they represent conditions in distinct sea basins,

10. Under favorable conditions, a local fauna may persist long after the normally associated groups have elsewhere perished.

The above are but a few of the many considerations which the student should bear constantly in mind in attempting the correlation of distant or even adjoining strata.

As a basis for further study let us briefly examine the Waverly series as it appears in central Ohio. The headings will sufficiently forecast the conclusions reached and the reader is asked to postpone judgment as to their correctness until after perusing what follows and examining the tables of distribution of species.

III. Keokuk and Burlington Groups.

Upper Waverly. (Upper Logan.) Embracing shales and freestone (the latter disappearing north-eastward) susceptible of subdivision into several tolerably distinct zones.

Near Lyon Falls.	Ohio Geological Report.
Shale---------- 3 ft.	Waverly conglomerate---- 100–190 ft.
Freestone with a parting of shale. Syringothyris----------27 ft.	
Conglomerate I----------18 in.	
Shaly and siliceous layer--------10 ft.	Argillaceous and sandy shales, sometimes bitumenous-------65 ft.
Blue shale "lamellibranch layer?" siliceous flags----------30 ft.	Shales with bands of flagy sandstone----------295 ft.
Concretionary shale with Spirifer marionensis, etc---------30 ft.	Berea sandstone.

This section corresponds, with a variation of only a few feet, with that seen below Rushville as far as exposed, that is to the conglomerate II, below which it agrees essentially with the Licking county exposures. The calcareous nodules and surrounding shale contain a rich fauna exactly equivalent to the Moot's run horizon (No. 13.) being characterized by *Spirifer marionensis*, *Streblopteria fragilis*, *Pterinopecten cariniferus*, etc. The freestone is somewhat contracted and less fossiliferous and shows premonitory symptoms of its decline further north-east. Further west in Richland and Knox counties one or both of the conglomerates are thickened at the expense of the remaining strata.

Sciotoville.	Rushville, Etc.	Ashland Co.
Carboniferous Congl.	Chester limestone.	
	Sandy shales---------25 ft.	
	Freestone, Phil. mermacensis, Phil. serraticaudata ----------30 ft.	Shales, Phil. serraticaudata---------- 20 ft.
Freestone and shales, Spirifer striatiformis ---------- 50 ft.	Shales and freestone	Freestone and shale, Spirifer striatiformis ----------30 ft.
	Spirifer striatiformis, Schizodus newarkensis--15 ft.	
	Shale---------- 30 ft.	
Freestone with Productus arcuatus----50 ft.	Freestone, Prod. arcuatus, etc ----------10 ft.	Freestone, Prod. arcuatus----------18 ft.
Shale.	Shale ----------30 ft.	Shales----------50 ft.
(Conglomerate II.)	Conglomerate II.	Congl. II------- 3 ft.
Freestone -------20 ft.	Shale, Sanguinolites obliquus, etc--------- 7 ft.	Shales, Sang. obliquus ---------- 5 ft.
Shale ---------- 20 ft.	Freestone, Syringothyris cuspidatus, Proetus auriculatus----------30 ft.	Freestone, Proetus auriculatus, Syringothyris cuspidatus--27 ft.
Freestone S. cuspidatus, etc.	Shale ----------15 ft.	Shale.

Sciotoville	Rushville, Etc.	Ashland Co.
(CONGL. I, absent.)	CONGLOMERATE I.	CONGL. I ------18 in.
Shales ----------40 ft.	Shales, Palaeoneilo attenuata, etc----------30 ft.	Flags and shale --10 ft.
	Shales and flags ----40 ft.	Siliceous flags----30 ft.
Spirifer marionensis, shales and flags, 70 ft.	Shales concretions, Spirifer marionensis------30 ft.	Concretionary shales, Spirifer marionensis, ----------30 ft.
	Flags and shales----70 ft.	
	Flags, unfossilif.---125 ft.	
	Shales, fossils-------10 ft.	Flags and shales.
	Berea grit, etc--100–175 ft.	

Our own observations are less full and connected further north, and a marked lithological change accompanied by the gradual disappearance of many of the mid-Waverly horizons produces a somewhat peculiar habitus as we enter the Cuyahoga valley. The few feet of shale near the top at Cuyahoga Falls seem to extend above any of the southern horizons and mingle fossils like Spirifer biplicatus of the Waverly with coal-measure types like Entolium aviculatum. The mistake has been made of regarding these shales as homogeneous. An almost entire change in fauna appears a mile or two below Cuyahoga Falls and there is little in common between the upper shales and those below the flags forming the second falls of the Cuyahoga. The following section is given by Dr. Newberry in Summit county:

Conglomerate. (Base of coal-measures)	
Cuyahoga shale	150–200 ft.
Berea grit	60 ft.
Bedford shale	70 ft.
Cleveland shale	50 ft.
Erie Shale	100–125 ft.
Huron shale	

The entire section, including the Erie and Cleveland shales which disappear further south, is less than 500 feet, and, making the necessary allowance, about 350 feet will include all of the Waverly which has an equivalent represented in central Ohio.

We may now pass to a more detailed study of the recognized horizons in Ohio.

1. *The Cuyahoga shale and Logan group.*

The term Cuyahoga shale is most misleading and can serve only to indicate the condition of the geological column in the northern tier

of counties. Instead of being a homogeneous unit of this column it is itself a curious patch-work mingling the most diverse elements of the series as seen further south and yet possessing a certain unity, due chiefly to the lithological similarity and hence the similarity in conditions of deposition of its various strata. Prof. Orton has called attention to this error as indicated by the lithological diversity of the various elements which Prof. Newberry's name is made to include, but we can more emphatically repeat his strictures from the standpoint of palæontology. The upper part of the series possesses a sub-carboniferous character and can be almost certainly parallelized with the shales in the upper part of the section as it appears in Licking county though it has some elements belonging to itself. *Conularia newberryi*, *Nucula houghtoni*, *Spirifer biplicatus*, *Entolium aviculatum*, *Spirifer setigera*, *Crenipecten*, sp. *Phillipsia immaturus*, etc., are among the common fossils.

This upper portion has been thought to be devoid of fossils but will yield a good harvest to the patient collector. It must not be confused with the lower fossiliferous horizons of Bagdad, Lodi and Weymouth. The fossils of this horizon are in part shown upon Plate X, Figs. 2—28 and 36—40. This layer lies *only forty feet below the conglomerate* at Cuyahoga Falls. The concretionary shales at Lodi and Weymouth extend *over one hundred* feet below the carboniferous conglomerate and present us with a very different association of fossils, the lower part of which contains some elements of a like concretionary zone of thirty or forty feet in thickness in Ashland county, there seventy feet below conglomerate I and one hundred and eighty feet or more below the carboniferous conglomerate and at least one hundred and fifty feet below the strata regarded as equivalent to the Cuyahoga shales. This latter horizon can be seen at Moot's run in Licking Co., where it is about two hundred and fifty feet below the carboniferous conglomerate.

The whole middle Waverly as seen in the central and southern part of the state is absent or only here and there present in its shaly strata. The equivalent of the shale below conglomerate II may be seen in parts of Medina county but only locally fossiliferous. That portion of the Cuyahoga shale below this concretionary layer is as yet insufficiently known, but contains four species of Lingula and will ultimately prove fruitful. Where it reposes on the Berea it bears *Lingula melie*, and *Orbiculoidea newberryi*, as it does in central Ohio and, as

there, tends to develop bitumenous bands. The fact that the Crinoids of Richfield are essentially Burlington species is not surprising in view of the fact that the strata represented by the Upper Cuyahoga in central Ohio are purely carboniferous with evident Burlington alliances. The evidence on this point afforded by the report of Mr. Ulrich, printed in this number is especially important. We can safely assert that the crinoids of the Cuyahoga shales in northern Ohio indicate an age not earlier than Burlington, the bryozoa of the same horizon in northern, central and southern Ohio indicate an age corresponding to the Keokuk and Burlington while the Logan fossils of other groups, for example, ***Phillipsia meramecensis***, indicate the same age. We submit therefore, that the upper one hundred feet of the Waverly are no longer doubtful—they are certainly of Carboniferous age and contain a fauna extending from the Burlington into or through the Keokuk groups. The term "Cuyahoga shale" can only be retained as a topographical designation.

Prof. Orton, with some reservation in view of further observation, suggests a division of the Cuyahoga shale into an upper and lower division, for the first of which he uses the term Logan, retaining the name Cuyahoga shales for that part below the conglomerate I, and extending to the black or Berea shale containing Lingula melie. To this, two suggestions must be offered. First, the term Cuyahoga shale was applied especially to the upper part, as all the writings of Newberry show, and this upper portion actually contains a part of the proposed Logan. Second, the Logan is both lithologically and faunally composite and consists of a number of distinct portions which are in fauna more unlike than the lower shale and the Logan. We have shown already at sufficient length the nature of the distinctions between the upper and middle divisions. The term "Waverly conglomerate" is especially unfortunate as the developments of conglomerate, as already shown, are local and may represent either conglomerate I or II, which are separated by a long and important interval.

In view of the above considerations we suggest the following modification of Prof. Orton's scheme, hoping to avoid the difficulties incident to the earlier plan of Dr. Newberry without introducing ambiguity into the terms employed:

"*Cuyahoga or Waverly series.*"

- Logan — Keokuk / Burlington — 100–150 ft.
- (Conglomerate II.)
- Kinderhook 50–60 ft
- (Conglomerate I.)

Berea or Transition series. (Western equivalent of upper Chemung.)	Waverly shale	40 ft.
	Berea shale*	200--400 ft.
	Berea grit	50--60 ft.
	Bedford shale	50 ft.
	Cleveland shale (local)	50 ft.
Erie shale, Eastern or typical Chemung (lower part)		100 ft.

2. *The Middle Waverly or Kinderhook Division.*

In as much as this important division is quite absent in the northern and eastern localities, a great deal of misapprehension has arisen which is quite uncalled for. The geologists who have worked only in the Cuyahoga valley habitually under-estimate the significance of this the most fossiliferous portion of the series. The middle Waverly is essentially a littoral zone and its fossils are for this reason largely peculiar, but it can be readily shown that Prof. Alexander Winchell was correct in identifying this horizon with the Kinderhook, etc., of the west. We do not claim that no fossils of the Kinderhook occur above conglomerate II or below conglomerate I, for this would be contrary to all analogy, but we do believe that, as a rather distinct factor of the Ohio Waverly, this may be wholly referred to that age and is its specific equivalent. That this horizon is equivalent to the Catskill of New York, as suggested by Winchell, would be in our judgement too specific a claim. The Catskill is another such a local development but it is more intensely local as it is a restricted member of the Chemung series, itself a littoral and provincial deposit. Very strict correlation of strata deposited under diverse conditions may never be possible. Chronological and faunal equivalences are rarely strictly identical. We may safely say that our middle Waverly is *representative of* the Catskill, and that is enough It is not necessary to reherse the accumulated evidence to show that this group is more closely allied to the upper Chemung than the Carboniferous limestones of the west. The species which give to the Waverly its carboniferous aspect as maintained by all writers, are largely from division iii. Nevertheless, the transition is gradual and almost imperceptible. The following are a few of the species which substantiate the identity with the Kinderhook. (It should be observed that the fossils of the lower sandy portions of the Burlington have been referred to the Kinderhook, hence quite a number of so-called Kinderhook species occur in our division iii). Conocar-

*This term includes not only the black shale, so called by Prof. Orton, but the greater part of the shales below the Kinderhook.

dium pulchellum, Nucula iowensis, Sanguinolites rigidus, Spathella ventricosa, Mytilarca fibristriata (below), Dexiobia ovata, Syringothyris sp., Edmondia burlingtonensis, Goniatites lyoni, Murchisonia quadricincta, Bellerophon cyrtolites, Productus arcuatus, P. Shumardianus, Chonetes logani, etc.

3. *The Waverly Shale.*

This term is given to forty feet of very fossiliferous shale below conglomerate I, and perhaps most closely related to our division II. The fossils are generally identical with Michigan species, such as, Palaeoneilo attenuata, P. elliptica, Orthonota rectidorsalis, Sanguinolites unioniformis, etc. This section contains a number of Kinderhook species with a sprinkling of those of the preceeding horizons. We have for convenience classified it with the Berea or Transition series.

4. *The Berea Shale.*

This is equivalent to the Cuyahoga shales of Orton minus the above mentioned shale. Instead of being as Prof. Orton states almost unfossiliferous, this division is one of the most interesting in the state, preserving its fossils, thanks to the calcareous concretions, in perfect condition. The species are mostly new to science but have analogies with Chemung and Hamilton forms. The bryozoa have not furnished conclusive evidence, most of them being new. The upper thirty or forty feet contain the concretions with three or four new trilobites, and Spirifer marionensis, Fenestella herrickana, Lyriopecten ? cancellatus, Pterinopecten cariniferus, Streblopteria fragilis, Promacra ? truncata, etc., are characteristic species. Traces of the same fauna can be followed downward over 100 feet. The lower part of this shale to the Berea contains a fauna as yet unstudied. The difficulty of securing specimens is extreme. Several days labor during which the shale was systematically examined bit by bit, inch by inch, have yielded about half a dozen species in obscure fragments. A spirifer apparently intermediate between Sp. marionensis and Sp. disjunctus, a Chonetes like C. scitula, a Palæoneilo like P. sulcatina, a Schizodus somewhat elik S. medinaensis, a fine Pleurotomaria, Palæoneilo consimilis and a Proetus being the entire find. The patient student will perhaps secure added material from exposures of this horizon one mile east of Harlam and four miles west of Jersey.

5. *The Berea Grit.*

The thickness of this horizon varies considerably. The grit proper

rarely exceeds sixty feet, but the superposed shales frequently become flags resembling it closely. These flags have yielded Atrypa reticularis and Strophomena rhomboidalis, the latter species, however, in the undisturbed deep sea fauna farther east, endured until the beginning of division iii. The only other fossils known from the Bera grit are found in the bitumenous layers overlying the grit. They are Orbiculoidea newberryi and Lingula melie.

In the northern part of the state the Berea is more distinct and may be divided into the lower or grind-stone grit and the upper or flag-stone division. The following section in Lorain and Medina counties will sufficiently illustrate the relations:

Carboniferous conglomerate		25 ft.
Cuyahoga, etc.	Shales with Chonetes illinoisensis, numerous bryozoa, etc	65 ft.
	Flags and shales with Spirifer biplicatus, Productus newberryi, etc	35 ft.
	Ferrugineous freestone with many fossils	20 ft.
	(Middle Waverly, absent.)	
Waverly and Berea shales	Shales with concretions with Strophomena rhomboidalis and fossils of horizon 80 feet below congl. I mingled with those of division III	30 ft.
	Unseen (perhaps)	150 ft.
Berea Grit.	Berea flags	40 ft.
	Grindstone grit	20 ft.
Bedford shale, (green and red)		50 ft.

6. *The Bedford shale.*

This member of the series has been the occasion of much perplexity. The so-called choccolate shales of central Ohio have frequently been identified with the Bedford of the lake region upon lithological grounds alone, the southern exposures being thought unossiliferous. As a matter of fact, they are everywhere abundantly fossiliferous. Especially prolific exposures occur near Central College, O. A number of the species occurring there are figured on Plate IX, and several of the same species are abundant in Summit county near Peninsula. One is at once struck by the fact that the group of forms here associated has nothing in common with either the Erie shale fauna or that of known exposures of the Waverly. The stratum rests directly on the the Hamilton* for much of its extent but overlaps the Erie shales in the north-eastern counties. Another fact is equally striking. The

*Prof. Orton, indeed, identifies the Cleveland shale in central Ohio, but in this we are unable at present to concur.

species are indistinguishable from or very like well-known Hamilton forms.

LIST OF FOSSILS FROM THE BEDFORD SHALE.

1. *Lingula melie*, H.
2. *Orbiculoidea newberryi*, H.
3. *Orthis vanuxemi*, H.*
4. *Chonetes scitula*, H.*
5. *Ambocoelia umbonata*, H.*
6. *Hemipronites*, sp.
7. *Macrodon hamiltonæ*, H.*
8. *Microdon bellistriatus*, Con. *
9. *Leda diversa*, var. *bedfordensis*, var n.(*)
10. *Palæoneilo bedfordensis* (=var. of P. constricta,)
11. *Pterinopecten*, sp.
12. *Bellerophon newberryi* ? (*)
13. *Bellerophon lineata*, H. ?
14. *Loxonema*, sp. (resembling *L. delphicola.**)
15. *Orthoceras*, sp. (resembling O. linteum.*)
16. *Goniatites*, sp. (resembling Portage sp.)
17. *Pleurotomaria* (cf. sulcomarginata.*)

One might conclude at once that this shale is little later than the Genessee but what seems like a well-warranted conclusion is quickly disturbed by the facts known concerning the subjacent strata in northern Ohio.

As above stated the Bedford reposes on the Black shale in central Ohio, but along Lake Erie two important members are interpolated, viz., the Cleveland and Erie shales.

Dr. Newberry has decided that the Bedford shale is carboniferous on the basis of such fossils, as *Syringothyris typa*, *Hemipronites crenistria*, *Chonetes logani*, *Orthis michelina*, and *Spiriferina solidirostris* and a few more. Having searched in the same localities without finding these forms in the typical Bedford as it appears in southern Ohio and on the other hand finding the species above mentioned we feel some hesitation as to the occasion of the confusion. These species may indeed occur below the Berea, but in flags and greyish shales *not in the blue or red Bedford shale!*

*Species so designated are of Hamilton age or closely related to such species.

6. *The Cleveland shale.*

This is a local bitumenous phase of great interest on account of the fish remains found in it. It may be omitted from our discussion as a local development reaching only the thickness of fifty feet and rapidly thinning out to the south. But that fact, and the fact that the Erie also becomes thicker to the north-east while the remaining strata grow thicker toward the south-west may occur to us in the light of a valuable suggestion. Meanwhile we pass to

7. *The Erie shale.*

This has heen a bone of contention. Probably the Devonian content of the lower Waverly would be admitted by everyone were it not that the fauna of the Erie is undoubtedly Portage or Chemung. It has yielded us, in the Cuyahoga valley near Peninsuala, the following species:

1. *Spirifer altus.*
2. *Spirifer disjunctus.*
3. *Spirifer præmaturus.*
4. *Leiorhynchus mesacostalis.*
5. *Streptorhynchus chemungensis.*
6. *Terebratula*, sp.
7. *Rhynchonella sappho.*
8. *Leiopteria*, sp.
9. *Orthoceras bebryx.*
10. *Productus* (like *lachrymosus.*)

To this list Prof. Newberry adds Orthis tioga, and others of unmistakable Chemung age. Dr. Newberry, in a private letter dated May 28th, 1888, reiterates the conclusions arrived at on the Geological Survey of Ohio, stating that "there is no foundation in fact for the union of the Cleveland, Erie, and Huron shales as the Ohio Black Shale. The Cleveland and Huron have nothing in common and in eastern Ohio are separated by 1000 feet of Erie shale which is upper Portage and Chemung. It (the Huron) represents everything in New York, from the Gardeau shale to the Marcellus inclusive, as I have taken from it in central and western Ohio fossils of the Portage, the Genessee, and the Marcellus shales, viz: *Goniatites complanatus, Leiorhynchus quadricostatus, Lingula spatulata, Discina lodensis, Lunulicardium fragile, Styliola fissurella,* and *Leiorhynchus limitaris.*"

The aspect of the Erie shale is exactly that of the Waverly shale

above the Berea and there seem to be several identical species but our time was too brief to collect systematically. A species of Syringothyris at least seemed to be common. The Bedford shale on the other hand seems more to resemble the Huron and in some places where it lies superposed on it is difficult to distinguish. Were it possible that this close interblending had escaped Dr. Newberry it would seem probable that some of the species attributed to the Huron are really Bedford.

All discussion of the age of the lower Waverly now turns upon the question as to the age of the Erie and Bedford, and this question stands in need of careful field-work and especially more extended and minute palæontological examination. Meanwhile the following suggestions may be hazarded. First, we may assume as proven that the Erie shales are of Chemung age, that is, in the broad sense, including Portage. The fossils, on the whole, indicate lower Chemung or Portage. Are we to conclude from this that all which lies stratigraphically above the Erie is certainly later faunally than the top of the Chemung as seen in New York strata? We think this does not by any means follow. We are struck in examining the stratigraphy of the Waverly by the fact that the dip of the true Waverly strata is south-east and the great area of its deposition is in a different basin from the Chemung. The Waverly strata thin out to the north-east while the Erie increases in thickness in the same direction. The point where the Erie and Waverly stata come into juxtaposition is not, however, along the shore of the Waverly sea, but far to the eastward of the littoral deposits. The two sets of rocks were formed then by different but occasionally interblended seas. The line of strike measurably conforms to the shore line in the Waverly. Thus the plane of 1000 feet elevation intersects the Moot's run horizon in Licking county and some distance west of Portsmouth in southern Ohio, while at Lodi the same horizon seems nearly at 825 feet probably, throwing the line of intersection further toward the west. There has not been any considerable change of level since the sediments were deposited beyond the gradual sinking of the centre of the basin. It is evident that the Devonian basin in New York and that of the Carboniferous in Ohio are not coincident nor have their movements followed the same rhythm.

When the strata which constitute the Chemung in New York were forming, what was going on in Ohio?

There seems to have been a pretty general uniformity of condi-

tions during the Hamilton period over the entire area considered—indeed a much more extensive one. The change which made the sediments of New York littoral sands and induced a modification of fauna may not have been felt at once in distant areas in Ohio. The undisturbed seas in Ohio may have been concealing a fauna closely allied to the Hamilton, while the oscillation along the western border of the Chemung area may have once and again thrown a great apron of its own sediments over Hamilton beds, only to be in turn covered by a similar apron from the Ohio ocean.

What, indeed, is to prevent us from believing that when the early fluctuation of the north-eastern part of this area was bringing more and more of the Silurian shore-line within its own erosive power and accumulating coarse detrital material in great masses, the weedy sea of the Hamilton continued unaltered in Ohio. Sandy bottom, stormy waves and unaccustomed conditions of all kinds must have their effect on the organization of the fauna and, if accepted ideas of the causes of evolution are correct, a sudden change would be seen in a faunal development more or less forced, one-sided, and local.

Great variety within narrow groups is the rule under such conditions. Just as the sudden formation of a prairie out of a morass develops hundreds of species in a few genera, so, in this case, such groups as could cope successfully with the new conditions would expand while others disappear. As the agitation extended westward the plot thickens. Somewhere on the western part of our area we should expect to find strata strangely interblended, just as a player in cutting and shuffling a pack thrusts the edges of the cards between each other. Here we should find a stratum marking the return of the former conditions.

Such a state of things as we have supposed would explain the conditions in northern Ohio in the period before the Berea grit, which put an end to all this by calling in the agency of shore action on its own account in the western part of the basin. Of this there is abundant evidence in the oblique lamellation and fucoids of that horizon. If we admit the probability that Hamilton and New York Chemung played a game of hide and seek during the preliminary oscillation they certainly were sadly disturbed during the Berea epoch.

Then followed a gradual depression with occasional infiltration from the Chemung area, now rapidly contracting. The Berea shales mark the long period of isolation and gradual depression. When the

subsequent upheaval began the sea must have extended as far as to the northern highlands and, after gnawing away at their bases and storing up great reservoirs of material, there began the gradual depression which spread them over the whole of the area. Time was then ripe for the opening of the Carboniferous period. The old descendants of Hamilton forms had done what they could, assisted by strays from the Chemung areas further east and having grown sadly out of fashion they were now subjected to nearly the same influences which were applied in the Chemung area. Littoral action and coarse sediments soon bore fruit in a fauna very like the later Chemung, though that period was now closed in New York.

Thus grew up our Kinderhook or middle Waverly. But a temporary recession swept the waters backward depositing a shale containing a few descendants of the old Waverly-shale fauna with interspersed forms of Carboniferous types. It was now sub-carboniferous time and the elevation which next followed left its trail of sandy material with a fauna not unlike the Burlington but so hastily retreating as to build no limestone fortifications. But in the far south-east now these limestones gathered strength and with the next gain of Neptune flung a thin apron over the lap of southwestern Ohio into which stormy Coal-measure seas cast millions of tons of stones worn by the universal torrents from the northern shores.

Of course this is a fabric of the imagination, but does it not explain in some measure rationally the complicated problem of the Waverly?

There can be little doubt that the materials of middle Waverly sandstone and conglomerate were carried by rivers or the like. The epoch of coal-measure conglomerate we have also spoken of as a torrent period. On what grounds? 1st. The accumulation of tree trunks of carboniferous aspect. 2nd. The nature of the deposits. 3rd. The fickle distribution of the materials. 4th. The combination of new and old material in its make-up, etc. How is the sudden and simultaneous advent of this rainy season explained? Did we not hear but yesterday that the axis of mother earth took a tilt northward disturbing all conditions? May not the inauguration of this change have been a gusty epoch? Incidentally we have showed how the composite character of the upper part of the Cuyahoga shale is to be understood.

It is not intended to carry out this speculation so far as to formulate an hypothesis. To the experienced student the few hints offered

may be sufficient to indicate at least a partial escape from the apparent dilemma introduced by the results of palæontological study*.

ADDENDA.

PTERINOPECTEN LÆTUS. H.

(Plate V, Fig. 13.)

A single left valve which cannot be distinguished from the quoted Portage species, was found at Moot's run.

SPIRIFER KEOKUK.

Specimens of this or a closely allied species occur in the upper layers at Rushville and Loudonville.

LEIOPTERIA ?? NEWBERRYI, sp. n.

(Plate XI, Fig. 31; also Vol. III, Plate VII, Fig. 36.)

This species is anomalous, at least we know no close analogue in any Carboniferous or Devonian genus. From any of the species here described it may be distinguished by the great height and uniform

*Prof. Orton's statement that the Cleveland shale is identified in central Ohio, is contrary to all statements of other geologists and apparently very slightly supported by observation. There is a considerable lithological difference between the Cleveland shale of northern Ohio and the Huron near Columbus, though Prof. Orton identifies one with the other, apparently without regarding the difficulty of disposing of the great Erie shale with its Chemung fossils, which separates them at the north.

It is not at present possible either to affirm or deny the extension of the Erie to the south-east, as the testimony of drilled wells is very ambiguous where minute differences and especially when palæontological considerations are in question.

A glance at Prof. Orton's useful map and sections of the Berea will strongly reenforce the view here presented. The south-eastward extension of the Waverly basin as contrasted with the north-eastward extent of the Chemung area is very obvious. The thickening of the Erie and Cleveland shales will be seen to correspond nearly to a change in dip, the line of which forms an anticlinal south of Akron, etc. So far as can now be gathered the red or true Bedford shale does not extend far to the north-east in Ohio. The great thickening of the Berea grit to the north-east is addition evidence of the near proximity of the shore of the Berea sea. At Youngstown there are about 150 feet of Berea, at Martin's Ferry 130 feet.

convexity of the posterior margin. The beak is about one-fourth from the anterior extremity. Anterior margin short, oblique, terminating in a rather acute angle at the lower margin, which is gently curved. The hinge-line is oblique to the axis and nearly straight. The surface is quite convex and marked only by concentric lines of growth.

It is possible that the species is related with Spathella or Modiola rather than Leiopteria. A second species or variety is figured on Plate V, Fig. 12, of vol. III. This is proportionately more elongate and has the lower outline somewhat sinuous at a point near the front where a sinus passes over the surface toward the umbo. The posterior wing is also more strongly extended, yet we suspect these both fall in a single species. The first above described form is apparently from the highest horizon of Div. III, i. e., Keokuk or upper Burlington, while the latter is from a lower zone in the same division at Newark. Comparative measurements may be taken from the figures as the specimens are not now available.

AVICULA ? RECTA, sp. n.

(Plate X, Fig. 13.)

Shell scarcely oblique, broad and flat, expanded below; hinge about one-half the height; posterior wing small, obscurely rounded, posterior margin nearly straight, forming an angle of about 15° with the hinge; anterior wing large, nearly rectangular, separated from the body by a depression forming an angle of 45° with the hinge, anterior outline with a shallow sinus at the juncture of the ear and body; front margin broadly elliptical. The surface is marked by strong, unequal, concentric grooves and striæ. Length of hinge, 6.5 mm.; height, 12 mm.; greatest length 10 mm.

Cuyahoga shales at Cuyahoga Falls, 30 feet below the conglomerate.

SOLENOMYA ?? CUYAHOGENSIS, sp. n.

(Plate X, Fig. 1.)

Shell minute, resembling in most ascertainable characters S. anodontoides of the coal-measures, but less expanded posteriorly. This may prove to be a young specimen of an Edmondia. I will not give a formal description but refer to the figure for all known details. Length, 6 mm.; height, 3.5 mm. Cuyahoga Falls, 30 feet below the conglomerate.

SCHIZODUS TRIANGULARIS, Her.

(Plate VI, Figs. 10, 13.)

Macrodon ?? triangularis, HERRICK. Bul. Den. Univ. vol. III, p. 74, Plate VIII, Fig. 8.

The poor specimens encountered last year gave an entirely false impression of this species. We have figured two typical (but, in size, extreme) examples of the species which show that the specimen figured last year, like many others seen, had lost the narrow posterior margin. The description may be emended as follows:

Shell large, sub-triangular in outline, apparently unusually thick for the genus. Hinge-line very short; anterior margin nearly straight or even slightly concave with the antumbonal convexity apparently springing abrubtly from the edge, which forms a large angle with the hinge; posterior margin nearly straight, very oblique to the hinges very near the post-umbonal ridge, post-umbonal slope very strong; lower outline a gentle convex curve broken by a slight sinus posteriorly. Surface convex, with a shallow groove in front of the post-umbonal ridge, which is strongly marked.

The very narrow and strongly depressed post-umbonal portion is characteristic of the species and, as even this was hidden or broken off in all of our earlier specimens, the resulting form seemed quite anomalous. This species seems so unlike the associated species as to require no comparison. It is limited to the freestone of the middle Waverly.

PLEUROTOMARIA STELLA, Win?

(Plate X, Fig. 41.)

"Shell minute, trochiform, composed of four and a half closely oppressed whorls, forming an apical angle of about 90°. Suture linear, inconspicuous, the flat sides of the whorls all lying in the same plane. Body whorl regularly rounded, marked by a raised bilinear band situated a little above the peripheral line, and on the whorls of the spire nearly concealed. The body whorl is ornamented by a line of minute tubercles running close to the suture, and occupying a feeble revolving ridge. No indications can be seen of transverse striæ connected with the tubercles.

Aperture subcircular; with the columellar lip reflected over the umbilicus. Some sharp incremental lines rise from the umbilical de-

pression and extend across the body of the shell. Height, .16 in.; width. .20; height of body whorl, .14; height of aperture, .9; width of band at aperture, .02; number of tubercles in one-tenth inch, 12."

Though somewhat larger our specimen agrees in all visible characters with the Michigan species.

From shale above conglomerate II, at Newark, where it is associated with *Orbiculoidea pleurites*, *Lingula waverlyensis*, *Allorisma consanguinatus*, *Conularia newberryi*, etc.

SCHIZODUS HARLAMENSIS, sp. n.

(Plate VI, Fig. 2.)

Shell small, subtrigonal, considerably longer than high, rather flat; beak prominent and produced; anterior side nearly at right angles with the basal and hinge margin, abruptly rounded above and below; lower margin nearly straight and parallel to the hinge; posterior margin but slightly oblique, moderately curved; central lower surface a triangular plane, posterior to which the post-umbonal slope slopes as a more oblique plane to the margin, while the ant-umbonal portion is more convex. Surface smooth except for the usual fine concentric striæ. In this species we see a link between Chemung and Waverly forms, if indeed, this does not prove identical with a Chemung form. The resemblance to Schizodus medinaensis is unmistakable. One mile east of Harlam, Delaware Co. In shales a few feet above the Berea flags.

PLATE I.

Figs. 1–3. *Proetus* (*Phillipsia* ?) *præcursor*, Her. ---- p 54.
Figs. 4–5. *Phaethonides spinosus*, Her. ---- p. 58.
Fig. 6. *Phillipsia meramecensis*, Shum. ---- p. 54.
Fig. 7. *Proetus minutus*, Her. Camera drawing of nearly perfect individual, highly manified ---- p. 56.
Fig. 8. *Phillipsia serraticaudata* ---- p. 52.
Figs. 9–15. *Phaethonides immaturus*, Her. ---- p. 59.
Fig. 10. *Phaethonides occidentalis*, Her. ---- p. 57.
Fig. 11. *Phillipsia serraticaudata* ? ? hypostome ----
Fig. 12. *Proetus* (*haldemani* ?) ---- p. 55.
Fig. 13. *Proetus* (*Phillipsia*) sp. close to P. auriculatus ---- p.
Fig. 14. *Proetus* (*Phillipsia*) *ariculatus*, H. (=*shumardi*) ---- p. 54.
Fig. 16, *Phillipsia* (?) *consors*, Her. ---- p 53.

PLATE II.

Fig. 1. *Hemipronites crenistria*, 10 ft. above Ohio river at Sciotoville----p. 24.
Fig. 2. *Spirifer marionensis*, Portsmouth----p. 26.
Fig. 2a. Surface characters, highly magnified.
Figs. 3–10. *Spirifer* (resembling *altus*) Moots' run, calcareous concretions.
Fig. 4. *Spirifer* (tenuispinatus) sp. n. Moots run----p. 27.
Fig. 5. *Hemipronites*. Young individual. Moots run----p.
Fig. 6. *Spirifer*, sp. Top of section near Newark Div. III----p.
Fig. 7. *Spirifer deltoideus*, sp.n. Congl. I, Granville----p. 27.
Fig. 8. *Spirifer biplicatus*. Newark, Div. III----p. 25.
Fig. 9. *Spirifer striatiformis*, full grown dorsal valve. Newark, Div. III--p. 85.

PLATE III.

Fig. 1. *Lingula* (*scotia* var.) *waverlyensis*, Her.----p. 18.
Fig. 2. *Lingula gannensis*, Her. Dorsal valve, *b*. striæ enlarged----p. 17.
Fig. 3. *Lingula gannensis*, ventral valve----p. 17.
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Fig. 6. *Athyris ashlandensis*, Her ----p. 24.
Fig. 7. *Syrmgothyris*, sp. view of the interior of beak----p.
Fig. 8–9. *Terebratula inconstans*, Her.----p. 24.
Fig. 10. *Productus nodocostatus*. Upper Waverly----p. 24.
Fig. 11. *Spirifer disjunctus*, H. Erie Shale, Peninsula, O.
Fig. 12. *Grammysia ovata*, Her----p. 35.
Fig. 13. *Martinia præmatura*, H. Erie Shale.
Fig. 14. Tooth of fish.
Fig. 15. *Productus rushvillensis*, Her----p. 22.
Fig. 16. *Leiorhynchus ? richlandensis*, Her.
Fig. 17. *Productus* (*newberryi* var.) *annosus*, Her ----p. 20.
Fig. 18. *Rhynchonella marshallensis*, Win----p. 23.
Fig. 19. *Productus varicostatus*, Her----p. 19.

PLATE IV.

Ffg. 1. *Sphenotus valvulus*, 30 feet below congl. I.
Fig. 2. *Prothyris meeki*, Gann. Div. II.
Fig. 3. *Ctenodonta houghtoni ?* 30 feet below congl. I. Union Station--p. 44.
Fig. 4. *Palæoneilo curta*. Freestone, Div. II----p. 44.
Fig. 5. *Dexiobia ovata*. Near congl. II----p. 38.
Fig. 6. *Oracardia cornuta*, sp. n. Lamellibranch layer below congl. I--p. 42.
Fig. 7. *Dexiobia ovata*, Gann----p. 38.
Fig. 8. *Oracardia ornata*, sp n. Freestone, Granville----p. 43.
Fig. 9. Hinge view of same specimen.

Fig. 10. *Oracardia ornata*. Large specimen ---------- p. 43.
Fig. 11. *Nuculana*, sp. Gann. near congl. II.
Fig. 12. *Nuculana*, sp. Freestone, Granville.
Fig. 13. *Nuculana similis*. Below congl. I.
Fig. 14. *Palæoneilo consimilis*. Shale 1 mile east of Harlam, O ---------- p. 43.
Fig. 15. *Palæoneilo ignota*. Moots run ---------- p. 44.
Fig. 16. *Nuculana saccata*, ? Below congl. I.
Fig. 17. *Palæoneilo sulcatina*. 30 feet below congl. I.
Fig. 18. *Palæoneilo ? marshallensis*. Div. III, Rushville ---------- p. 43
Fig. 19. *Macrodon newarkensis*. Div. III, Newark ---------- p. 36.
Fig. 20. *Spathella ventricosa*. Freestone, Granville ---------- p. 31.
Fig. 21. *Mytilarca fibristriata*. Moot's run ---------- p. 31.
Fig. 22. *Nuculana diversa ?* Peninsula, O.
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PLATE V.

Fig. 1. *Edmondia sulcifera*. Right valve, Moot's run ---------- p. 30.
Fig. 2. Hinge view of smaller valve of same species.
Fig. 3. *Crenipecten cancellatus*. Moot's run ---------- p. 34.
Fig. 4. *Leiopteria* (*Leptodesma*) *ortoni*, largest specimen yet collected, 40 feet below conglomerate I.
Fig. 5. *Leiopteria*, sp. Freestone.
Fig. 6. *Leptodesma scutella*. Freestone, (Cf. vol. iii, Plate IV) ---------- p. 30.
Fig. 7. *Conocardium* (Cf. alternistriatum). Moot's run ---------- p. 40.
Fig. 8. *Leiopteria*, sp. Freestone.
Fig. 9. *Crenipecten caroli*, ? Gann. freestone.
Fig. 10. *Streblopteria*, Gann. Freestone.
Fig. 11. *Avicula* (?) *subspatulata*, sp. n. Div. III, Newark ---------- p. 20.
Fig. 12. *Pterinopecten cariniferus*, peculiarly modified left valve ---------- p. 33.
Fig. 13. *Pterinopecten lætus*. H. Moot's run.
Fig. 14. *Crenipecten crenistriatus*. Div. III, Newark ---------- p. 34.
Fig. 15. *Streblopteria*, sp. Div. III, Newark.
Fig. 16. Crinoid arm, Sciotoville.

PLATE VI.

Fig. 1. *Schizodus prolongatus*, Her. Lamellibranch layer ---------- p. 36.
Fig. 2. *Schizodus palæoneiliformis*. Freestone.
Fig. 3. *Schizodus harlamensis*. 1 mile east of Harlam.
Fig. 4. *Sphenotus* (*Cypricardia*). Lamellibranch layer.
Fig. 5. *Grammysia famelica*, Her. ---------- p. 35.
Fig. 6. *Schizodus newarkensis*, Her. Tank, Newark ---------- p. 36.

Fig. 7. *Macrodon*, sp. Moot's run.
Fig. 8. *Cypricardinia scitula*, Her. Moot's run ..... p. 38.
Fig. 9. *Macrodon reservatus*. Freestone.
Fig. 10. *Schizodus triangularis*, Her. Freestone ..... p. 116.
Fig. 11. *Grammysia* (?) *hannibalensis*, Shum. Freestone.
Fig. 12. *Schizodus quadrangularis*, H. Freestone.
Fig. 13. *Schizodus triangularis*, Her. Freestone ..... p. 116.
("Macrodon ?? triangularis," of vol. iii.)

PLATE VII.

Fig. 1. *Orthoceras rushensis* ? 30 feet below congl. I.
Fig. 2. *Goniatites lyoni*. Freestone.
Fig. 3. *Nautilus*. Moot's run.
Fig. 4 Moot's run.
Fig. 5. *Euomphalus latus*. Freestone.
Fig. 6. *Murchisonia*, sp. Moot's run.
Fig. 7. *Loxonema*, sp. Tank, Newark.
Fig. 8. *Nautilus*, sp. Tank, Newark.
Fig. 9. *Pleurotomaria strigillata*. Freestone.
Fig. 10. *Pleurotomaria* (*Flemingia*) *stulta*, Her. Freestone ..... p. 43.
Fig. 11. *Pleurotomaria vadosa*, Win. ? 1 mile east Harlam.
Fig. 12. *Platyceras zomerum*, Win. ? Moot's run,

PLATE VIII.

Fig. 1. *Platyceras lodiensis*, var. ? Bagdad, O ..... p. 46.
Fig. 2. *Conularia gracilis*, Her. 2a, the smallest specimen seen; 2b, the largest specimen seen, restored; 2c, camera drawing of a portion of the surface greatly magnified ..... p. 48.
Fig. 3. *Conularia victa*, White.
Fig. 4. *Conularia micronema*, Meek. 4a, camera drawing of surface magnified.
Fig. 5. *Conularia newberryi*. Camera drawing of surface magnified.
Fig. 6. *Zaphrentis* (?). Upper layers at Rushville.
Fig. 7. *Platyceras lodiensis*, ? Ashland Co.
Fig. 9. *Cythere ohioensis*, Her. Upper layers at Rushville ..... p. 60.

PLATE IX.

Fossils from Bedford shales at Central College.

Fig. 1. *Lingula melie*.
Fig. 2. *Discina*, sp.
Fig. 3. *Martinia umbonata*.

Fig. 4. *Macrodon hamiltonæ*, H.
Fig. 5. *Goniatites*, sp.
Fig. 6. *Strophomena rhomboidalis*. From shales above Berea grit.
Fig. 7. *Atrypa reticularis*. From shales above Berea grit.
Fig. 8. *Palæoneilo bedfordensis*, Meek.
Fig. 9. *Microdon bellistriatus*.
Fig. 10. *Orthis vanuxemi*?
Fig. 11. *Bellerophon helena*. ?
Fig. 12. *Pterinopecten*, sp.
Fig 13. *Nuculana diversa*, H.
Fig. 14. *Pleurotomaria sulcomarginata*. ?
Fig. 15. *Loxonema delphicola*?
Fig. 16. *Orthoceras*. sp.

PLATE X.

Fig. 1. *Solenomya ? cuyahogensis*, sp. n. ---------- p. 115.
Fig. 2. *Palæoneilo*, sp.
Fig. 3. *Edmondia*, sp.
Fig. 4. *Nucula houghtoni*, ?
Figs. 5, 6, 7. *Entolium aviculatum*.
Figs. 8–9. *Crenipecten*, sp.
Fig. 10. *Aviculopecten*, sp.
Fig. 11. *Aviculopecten*. sp.
Fig. 12. *Aviculopecten*, sp.
Fig. 13. *Avicula recta*, sp. n. ---------- p. 115.
Fig. 14. *Platyceras*, sp.
Fig. 15. *Macrodon* (allied to) *tenuistriata*.
Fig. 16. *Palæoneilo*, sp.
Figs. 17–18. *Spirifer biplicatus*.
Fig. 19. *Spirifer*, sp.
Fig. 20. *Spirifer hirtus*.
Figs. 21–22. *Orthis*, sp.
Fig. 23. *Atyris*, sp.
Fig. 24. *Productus newberryi* ---------- p 20.
Fig. 25. *Hemipronites*.
Fig. 26. *Chonetes*, sp.
Fig. 27. *Conularia newberryi*.
Fig. 28. Surface characters of an associated species of Conularia.

The above figures are intended to illustrate the nature of the fauna at the highest horizon of the Waverly, at Cuyahoga Falls, only 30 feet below the carboniferus conglomerate. These species have not been elaborated because it is hoped that Prof. Claypole of Akron, will soon give this region a careful study.

Fig. 29. *Lingula cuyahoga*, Hall.
Fig. 30. *Lingula atra*, sp. n. ---------- p. 16.
Fig. 31. *Lingula meeki*, sp. n. ---------- p. 18.
Fig. 32. *Lingula melie*, H. ?

Fig. 33. *Orbiculoidea newberryi*, H.....p. 12.
Fig. 34. *Allorisma cuyahoga*, sp. n.....p. 28.
Fig. 35. *Productus*, sp.
The above are from a horizon about 100 feet lower in Cuyahoga valley.
Fig. 36. *Fenestella albida*. var. ?
Fig. 37. *Pinnatopora intermedia*, Ulrich.
Fig. 38. *Pleurotomaria*, sp.
Fig. 39. *Rhynchonella*, sp. These from Cuyahoga Falls.
Fig. 40. *Chonetes*. sp. About 160 feet below conglomerate
Fig. 41. *Pleurotomaria stella*, Win Shale over congl. II.
Fig. 42. *Orbiculoidea pleurites*, M. Shale over congl. II.
Fig. 43. *Cypricardinia* ? sp. Highest horizon at Rushville.
Fig. 44. *Conocardium*, sp. Highest horizon at Rushville.

PLATE XI.

[Forms plate of same number in vol. iii.]

Fig. 1. *Mytilarca occidentalis*, White ?.....p. 32.
Fig. 2. *Platyceras lodiensis*, Meek.
Fig. 3. (*Phillipsia meramecensis* For this figure see Plate I, fig. 6.)
Fig. 4 *Pterinopecten ashlandensis*, Her.....p. 33.
Fig. 5. *Lyriopecten nodocostatus*, Her.....p. 32.
Fig. 6. *Macrocheilus ponderosus*. Coal measures.
Fig. 7. *Machrocheilus fusiformis*. Coal measures.
Fig. 8. *Naticopsis nana*. Coal measures.
Fig. 9. *Naticopsis nodosa*. Coal measures.
Fig. 10. *Macrocheilus paludinaeformis*. Coal measures.
The above from Fultonham, just above the Chester.
Fig. 11. *Productus parvus*. Chester limestone.
Fig. 12. *Allorisma andrewsi*. Chester limestone.
Fig. 13 *Allorisma consanguinatus*. Her. Shale over congl. II.
Fig. 14. *Spirifer increbescens* Chester limestone,
Fig. 15. *Spirifer glaber*. Chester limestone.
Fig. 16. *Nautilus bisuleatus*, Her. Chester limestone.
Fig. 17. *Lophoplyllum*, sp. Chester limestone.
Fig. 18. *Terebratula inconstans*, Her. Waverly.....p. 24
Fig. 19.
Fig. 20. *Cyrtina acutirostris*, Shum. Lodi, O.
Fig. 21. *Rhynchonella contracta*. Bagdad, O.....p. 23.
Fig. 22. *Rhynchonella marshallensis*, ? Lodi, O.....p. 23.
Fig. 23. *Spirifer increbescens*. From limestone fragments in coal measure conglomerate in Licking Co.
Fig. 24. *Conocardium alternistriatum*, Her.....p. 42.
Fig. 25. *Crenipecten cancellatus*, Her.....p. 34

Figs. 26,29. *Productus duplicostatus*, Win. Distorted dorsal and perfect ventral valve ..... p. 21.
Fig. 27. *Macrodon striatocostatus*, Her ..... p. 21.
Fig. 28. *Macrodon*. sp. Portsmouth.
Fig. 30. *Leiopteria nasutus*, Her. Bagdad ..... p. 29.

TABULATED LIST OF FOSSILS

Known to Occur in the Waverly of Ohio.

Compiled by W. F. Cooper.

The following list is designed to display at a glance the vertical position of all species reported from the Waverly group. While it is attempted to include all species reported in Ohio, it has not been possible to entirely eliminate synonomy and it is probable that some species have been overlooked.

Those species which have not been seen by us are indicated by an initial indicating, not the authority for the name, but the person upon whose observation the presence of the form in Ohio rests. Thus [W.] indicates Prof. Alex. Winchell, [H.] Prof. James Hall, [M.] Mr. F. B. Meek and [N.] Prof. J. S. Newberry.

The sub-divisions in the table are artificial, but correspond in a general way with the horizons and sub-divisions indicated in Prof. Herrick's papers. They are as follows: I, all below conglomerate I. I1, Bedford shale, I2, Berea grit, I3, lower part of Berea shale, I4, upper part of Berea shale (about 150 feet, up to within 40–60 feet below conglomerate I.) I5, Waverly shale (40 feet below congl. I.) II, Kinderhook division, II1, freestone of central Ohio, II2, shale below congl. II. III, Upper or Logan division, III1, shale over conglomerate II, III2 freestone and shale up to about 100 feet above congl. II, (Burlington), III3, upper layers (Keokuk) about 25 feet.

Additions and corrections to the list are solicited.

NAME.	Division I					Div II		Div III		
	1	2	3	4	5	1	2	1	2	3
PISCES.										
Cladodus pattersoni, [N.]				?						
Ctenacanthus formosus, [N.]										?
Gyracanthus alleni, [N.]									?	
" compressus, [N.]									?	
Orodus variabilis, [W.]				?						
Palæoniscus brainardi, [N.]		o								
CRUSTACEA.										
Cythere ohioensis.										o
" crassimarginata, [W-]									?	
Phaethonides occidentalis.							o			
" spinosus.										
" ? immaturus.				o					o	
" ? lodiensis.										
Phillipsia meramecensis.				?						o
" serraticaudata.										o
" ? consors				?						
" (Proetus) auriculatus,					o	o			?	
Proetus minutus.				o						
" doris, [W.]										
" præcursor.				o						
LAMELLIBRANCHTATA.										
Allorisma nobilis.						o				
" cooperi.						o				
" winchelli.							o			
" ventricosa.							o			
" convexa.							o			
" cuyahoga.									o	
" consanguinatus.								o		
Arca ornata.					o					
Arca modesta. [W.]										
Avicula (Leptodesma) scutella.						o				
" ? sub-spatulata.									o	
Aviculopecten perelongatus.						o				
" cooperi.				o						
" oweni.						?			?	
" whitei, [W.]										
" newarkensis.									?	
" occidentalis, [W.]										
" tenuicostatus, [W.]										
Cardiopsis (Dexiobia) ovata.						o				
Conocardium pulchellum.						o				
" alternistriatum									?	o
Crenipecten granvillensis.									o	
" subcardiformis.				o						
" senilis ?						?				
" crenistriatus.									o	o
" cancellatus.					o					
Ctenodonta iowensis				o	o					
" stella.										
" houghtoni.						?		o		

NAME.	Division I					Div II		Div III		
	1	2	3	4	5	1	2	1	2	3
Ctenodonta sectoralis, [W.]										
Cypricardinia (Microdon) scitula.				o						
Edmondia depressa.							o			
" burlingtonensis.					o					
" sulcifera.				o						
" aequimargintus, [W.]										
Grammysia ovata.									o	
" famelica.					o					
" rhomboides.							o			
" ventricosa							o			
" hannibalensis.						o			o	o
Leiopteria ortoni.				o						
" halli.						o				
" sp.				o						
" sp.						o				
" nasutus.				o						
" newberryi.										o
Leptodesma scutella.						o				
Limatulina ohioensis.									o	
Lyriopecten ? cancellatus.				o						
" nodocostatus.				o						
Macrodon newarkensis.									o	
" striato-costatus.				o						
" sp.				o						
Microdon reservatus.						o				
Modiola waverliensis.						o				
Modiomorpha hyalea						o				
Myalina michiganensis.						o				
Mytilarca fibristriatus.				o						
" occidentalis.									?	
Nuculana spatulata.					o					
" similis.					o					
" var.					o					
" sp.						o				
" sp.						o				
" nuculæformis ?										
" barrisi, [W.]								o		
Oracardia cornuta.					o					
" ornata.						o				
Orthonota rectidorsalis.					o					
Palaeoneilo elliptica.					o					
" plicatella.					o					
" elegantula.					o					
" marshallensis.				o	o	o		o	o	?
" allorismiformis.					o					
" attenuata.					o					
" ? ohioensis.				o						
" consimilis.		o								
" ignota.				o						
" (Nucula) curta.						o				
" sulcatina.				o						
Pholadella newberryi.						o	o			

NAME.	Division I					Div II		Div III		
	1	2	3	4	5	1	2	1	2	3
Promacra truncata.				o						
Promacra andrewsi, [M.]									?	
Prothyris meeki.							o	o		
Pterinea spinulata. [W.]										
Pterinopecten shumardianus.				o						
" carniferus.				o						
" ? ashlandensis.				o						
" lætus				o						
Sanguinolites senilis.					o	o				
" unioniformis.						o				
" flavius.					o					
" amygdalinus.					o					
" michiganensis.							o			
" æolus.							o			
" obliquus.							o			
" naiaditormis.						o				
Schizodus newarkensis.									o	
" chemungensis.						o				
" cuneus.						o				
" harlamensis.			o							
" medinaensis.						?				
" palaeoneiliformis.						o				
" prolongatus.					o					
" qadrangularis.						o				
" triangularis.						o				
Solen missouriensis, [W.]										
Spathella ventricosa.						o				
Sphenotus contractus.				o						
" transversus.						o			?	
Streblopteria squama.					o					
" gracilis.						o				
" fragilis.				o						
" media.				o	o					
GASTEROPODA, ETC.										
Bellerophon cyrtolites.					o					
" galericulatus.					o	o	o	?		?
" sp.				o						
" perelegans.					o					
" bilabiatus, [W.]										
" vinculatus, [W.]										
Conularia newberryi.						o	o	o	o	
" byblis, [W.]										
" victa.									o	
" gracilis.				o						
" micronema.				o		?				
" multicosta, [W.]										
Cyclonema leavenworthana.			?			o				
" strigillatum.				o		o				
Dentalium granvillensis.						o				
Euomphalus latus.						o				
" spirorbis.						o				
Flemingia stulta.						o				

NAME.	Division I					Div II		Div III		
	1	2	3	4	5	1	2	1	2	3
Goniatites lyoni,						o				
" sp.									o	
" andrewsi, [W.]										
" marshallensis, [W.]										
" ohioensis, [W.]										
" shumardianus, [W.]										
" sp.	o									
Gryoceras, sp.									o	
Loxonema yandellana.						o				
Murchisonia quadricincta.						o				
" prolixa, [W.]										
Naticopsis, sp.				o						
Nautulus trisulcatus, [W.]										
Orthoceras rushensis.				o	o	o				
" heterocinctum.				?						
" sp.	o									
Platyceras hertzeri						o				
" haliotoides.						o				
" bivolve						o				
" paralium ?						o				
" lodiensis.				?					?	
" vomerium, [W.]										
" subplicatum, [W.]										
Pleurotomaria textiligera									?	
" vadosa, [W.]										
" stella.										
" sulcomarginata.	o							o		
BRACHIOPODA.										
Ambocœlia umbonata.	o									
Athyris ohioensis.						o				
" lamellosa.				o						
" ashlandensis.			o							
" hannibalensis, [W.]										
" missouriensis, [W.]										
Atrypa reticularis.			o			o				
Centronella julia.									o	
" allei, [W.]										
" flora, [W.]										
Chonetes logani.		o		o			?		?	
" illinoisensis.										o
" scitula.		o		o						
" tumida.				o						
" pulchella.						o				
" planumbona ?										?
Cryptonella eudora.						o				
Crania hamiltonæ ?				o						
Cyrtina acutirostris.				o						
Discina gallaheri, [W.]										
Hemipronites crenistria.			o	o	o	o	o	o	o	
Lingula atra.									o	
" gannensis.								o		
" membranacea.									o	

NAME.	Division I					Div II		Div III		
	1	2	3	4	5	1	2	1	2	3
Lingula melie.	o	o								
" meeki.									o	
" waverliensis.								o		
Orbiculoidea newberryi.	o	o								
" pleurites.								o		
Orthis vanuxemi	o									
" pulchellus.							o			
" michellina						o				
Productus semireticulatus.							o		o	
" arcuatus.									o	
" burlingtonensis.									o	
" shumardianus.				o						
" concentricus				o						
" lachrymosus?				o						
" speciosus				o						
" gracilis.				o						
" raricostatus.				o						
" newberryi.									o	o
" (newberryi var?) annosus.				o						
" duplicostatus.									o	
" rushvillensis.										o
" nodocostatus.										o
" morbilliana, [W.]										
Rhynchonella contracta.				o		o			o	o
" subcuneata.						o				
" sageriana.						o				
" sappho.				o						
" marshaliensis.						o				
" sp.				o						
" hubbardi, [W.]										
" missouriensis, [W.]										
" pustulosa, [W.]										
Rhynchospira ashlandensis.				o						
Spirifer marionensis.				o						
" striatiformis.									o	
" biplicatus.									o	
" winchelli.							o	o		
" raricostatus, [W.]										
" hirtus.						o			o	
" (Martinia) tenuispinatis.				o						
" deltoideus.						o				
" keokuk.										o
" sillana?										
" subrotundata? [W.]										
" waverliensis? [W.]										
Spiriferina solidirostris.							o			
" depressa.						o				
Syringothyris cuspidatus.						o	o			
Terebratula? inconstans.				o						
CRINOIDEA.										
Actinocrinus helice. [H.]										o
" viminalis, [H.]										o

NAME.	Division I					Div II		Div III		
	1	2	3	4	5	1	2	1	2	3
" daphne, [H.]										o
Forbesiocrinus communis, [H.]										o
" lobatus, [W.]										o
" kellogi, [H.]										o
Platycrinus graphicus, [H.]										o
" contritus, [H.]										o
Poteriocrinus crineus, [H.]										o
" corycia. [H.]										o
" pleias, [H.]										o
Scaphiocrinus algini, [H.]										o
" lyriope, [H.]										o
" subcarinatus, [H.]										o
" subtortuosus, [H.]										o
Zeacrinus paternus, [H.]										o
" meriope, [H.]										o
BRYOZOA.										
Cystodictya zigzag.										o
" simulans.				o						
" angusta.				o						
Fenestella herrickana.				o						
" meekana										o
" foliata.										o
" aperta										o
" subflexuosa.										o
" albida.										o
" " var. richfieldensis.										o
" cavernosa.				?						
" regalis										o
" burlingtonensis,									?	
" tenax.										?
Glyptopora megastoma.									o	
Leioclema gracillimum.										o
" punctatum.									o	
Polypora impressa.										o
" gracilis.										o
" radialis.										o
Ptilopora paupera.										o
Pinnatopora intermedia.										o
" simulatrix.										o
" curvata.										o
" subangulata.										o
" minor.										o
" vinei.										o
" youngi.										o
" tenuiramosa.										o
Rhombopora confluens.										o
" incrassata.										o
" ohioensis.				o						o
Streblotrypa obliqua.										o
" amplexa.		•							?	
" hertzeri.										o

NAME.	Division I					Div II		Div III		
	1	2	3	4	5	1	2	1	2	3
" striata.										o
" regularis.										o
" amplexa.										?
" (? Leioclema) denticulata.										o
" major.										o
Tæniodictya interpolata.										o
CORALS.										
Pleurodictyum.						o				
ADDENDA.										
Macrodon hamiltonæ.	o									
Microdon bellistriatus.	o									
Leda diversa.	o									
Palæoneilo bedfordensis.	o									
Bellerophon newberryi ?	o									
" helena ? ?	o									
" lineata.	o									
Loxonema delphicola ?	o									
Platycrinus richfieldensis.										o
" lodensis.										o
" bedfordensis.										o

MISCELLANEOUS NOTES.

A Note on a Peculiar Habit of Fresh Water Hydra.

During the last of September, while examining, in the laboratory, an aquarium containing Hydrodictyon, Spirogyra and other plants, I noticed on the sides of the aquarium a few Hydras and, as the class in Zoology would need some for study about the last of November, I placed the vessel in a window and renewed the water from time to time and soon noticed that the Hydras were reproducing by budding very rapidly. As the time approached for the class to need them, there was quite a large number, with buds in all stages of development.

But, greatly to my surprise, in a day or two afterwards, when I went to the aquarium to get specimens for the class, there was not a single Hydra to be seen on the sides of the aquarium, where they had been so abundant. My first thought was that some one had disturbed them, but upon accidentally turning over a piece of bark that happened to be in the bottom of the glass, I found underneath it all the animals that had but two days before been attached to the sides of the receptacle.

Upon examination, I found that, without exception, they were all reproducing by means of eggs. The large ovaries, and testes, producing spermatozoa with two flagella, forming from the ectoderm in numbers as high as six on a single animal. By placing some of these animals in the light they again began reproducing by budding. Thus showing by a few simple experiments that the most common method of reproduction, by budding, takes place in the light, but when the animal reproduces by means of eggs it seeks the dark and becomes quite inactive. A fall in the temperature of the room might account for the sudden change observed, in this case, in the method of reproduction. The eggs, covered with a thick chitinous shell, falling to the bottom, pass the cold months in that state. Both forms of Hydra vulgaris, H. virdis and the one under cosideration, H. fusca, are quite common in this locality.

A more extended discussion of the Hydra may appear in a future issue of the Bulletin.

W. G. Tight.

List of Algæ from Granville, O.

The following list adds a number of species to that given by Mr. H. L. Jones in volume II.

1. *Spirogyra dubia.*
2. *Spirogyra adnata.*
3. *Spirogyra fluviatilis.*
4. *Spirogyra* sp. (see below.)
5. *Zygnema cruciatum.*
6. *Zygmena stellatum* (*genuinum.*)
7. *Oedogonium fragile.*
8. *Oedogonium polymorphum.*
9. *Chætophora fusiformis.*
10. *Conferva rhyphophila.* This plant grows in troughs and deep pools and stands perpendicular in great green masses resembling pillars. The stems are very fine threads and much crowded together.
11. *Oscillaria tenuis.*
12. *Oscillaria.*
13. *Hyalotheca mucosa.*
14. *Closterium acerosum.*
15. *Miscrasterias truncata.*
16. *Nostoc rupestre.*
17. *Wolfia columbiana.* (Not properly included in a list of *algæ*, but mentioned on account of its association.)

Numbers 1, 2, and 12 of the above list were found in a pond fed by a spring and had their filaments commingled. In like manner, 5, 6, 7, 9, and 16 were closely associated. The nostoc was very sticky, so that the stems of the other plants, spores, and debris clung to masses of it. When the spores developed, the stems would grow all about among the Nostoc fronds.

The Spirogyra numbered 4, appears to be undescribed. Should this prove to be the case I would wish to call it

Spirogyra herricki sp. n.

Diameter about 3 m.; cells 2½ to 4 times as long as broad; spirals 3, making 1½ to a little more than 2 turns; cells not folded or replicate at the ends; spirals rather narrow, light green; fertile cells swollen; spore 42 m. by 22 m.

Chas. L. Payne.